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

Master's Dissertation
International Master in Sustainable Built Environment

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July 2022

ACKNOLEDGEMENT

I would like to express my special appreciation and thanks to my supervisor Professor Dr. Luís M. Bragança M. Lopes, whose valuable advice and suggestions, and his endless support helped me complete this dissertation. Also, I wish to show my special gratitude to him, who made it possible for me to obtain a research scholarship from the University of Minho to use towards this dissertation project, which also helped me in doing a lot of research, and I came to grow in the field of sustainable developments knowledge. I would also like to thank to my second supervisor Professor Dr. Ricardo Filipe Mesquita da Silva Mateus, whose knowledge and expertise associated with the fulfilment of this research work, for his encouragement and continual help and advice. None of the works done during this master dissertation would have been possible if not for their guidance, effort, and commitment. They were always supportive, encouraging, and inspiring.

I am grateful to all of those with whom I have had the pleasure to work during this and other related projects. Also, many thanks and appreciations to my family and friends for helping me maintain perspective and have willingly supported me in this effort.

STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

I further declare that I have fully acknowledged the Code of Ethical Conduct of the University of Minho.

RESUMO

O conceito e a prática da sustentabilidade no planejamento urbano ganharam importância global desde o início dos anos 2000 e se tornaram cada vez mais comuns no processo de formulação de políticas. A adoção de estruturas globais como os Objetivos de Desenvolvimento Sustentável das Nações Unidas, padrões ISO para comunidades sustentáveis e Nível(is) é uma oportunidade para construir vilas e cidades mais sustentáveis, inovadoras e equitativas, com respeito aos recursos naturais e à biodiversidade. No entanto, alcançar a sustentabilidade requer abordar muitas questões fundamentais em vários níveis, e alcançar as metas e objetivos da sustentabilidade representa um grande desafio para todos os segmentos da sociedade. Portanto, a seleção de indicadores de sustentabilidade é essencial para medir com precisão o nível comparativo de sustentabilidade. E, os indicadores de sustentabilidade podem ser implementados de acordo com as limitações e especificações do contexto. No entanto, as ferramentas de avaliação podem nem sempre ser capazes de refletir o nível de sustentabilidade de forma objetiva ou precisa, se não houver estatísticas nacionais atualizadas e confiáveis. Portanto, é necessário refinar e evoluir os itens de avaliação, incorporando as mais recentes tecnologias, regulamentações e experiência na prática.

Neste sentido, esta investigação contribui para a melhoria do quadro de avaliação de bairros pré-estabelecido pelo iiSBE Portugal, SBToolPT_Urban. A ferramenta fornece orientações para avaliar a sustentabilidade à escala do bairro, em Portugal. Para melhorar o quadro pretendido, o estudo fez uma análise comparativa dos indicadores de três principais ferramentas de avaliação de bairro relevantes para o desenvolvimento urbano sustentável, iiSBE SNTool, BREEAM Communities e LEED for Neighborhood Development, com os indicadores pré-estabelecidos do iiSBE SBToolPT - Urbano como o caso desta pesquisa. Esta comparação e análise permitem identificar os indicadores negligenciados e os fatores essenciais relacionados com a sustentabilidade dos bairros urbanos que pela sua importância têm potencial para serem adaptados pelo SBToolPT-Urban, para o contexto de Portugal. Esses novos indicadores em potencial também são avaliados para estarem alinhados com as Diretivas da UE. Além disso, é analisado o alinhamento dos indicadores do SBToolPT-Urban com as estratégias promovidas pelo(s) Nível(is), ISO 37120 e ODS. Este resultado deste estudo pode ajudar a preencher as lacunas relevantes com a questão da sustentabilidade abordada pela ferramenta e entender seu alinhamento com os critérios e padrões mundiais de avaliação de sustentabilidade. Isso pode influenciar no monitoramento e identificação de áreas problemáticas em relação às questões de sustentabilidade e facilitar comparações de sustentabilidade ao longo do tempo em áreas de bairro, a fim de adaptar novas medições e desenvolver estratégias de melhoria.

ABSTRACT

The concept and practice of sustainability in urban planning have gained since the early 2000s global significance and have become increasingly mainstream in the policy-making process. The adoption of global frameworks like the United Nations Sustainable Development Goals, ISO standards for sustainable communities, and Level(s), is an opportunity to build more sustainable, innovative, and equitable towns and cities, with respect to natural resources and biodiversity. However, attaining sustainability requires addressing many fundamental issues at various levels, and achieving the goals and objectives of sustainability presents a great challenge for all segments of society. Therefore, the selection of sustainability indicators is essential to accurately measure the comparative level of sustainability. And, the sustainability indicators can be implemented according to the context limitations and specifications. However, the assessment tools may not always be able to reflect the level of sustainability objectively or accurately, if lacking the up-to-date and reliable national statistics. Therefore, refining and evolving of the assessment items is necessary, incorporating the latest technologies, regulations, and experience in practice.

In this regard, this research contributes to the improvement of the pre-established evaluation framework of neighbourhoods by iiSBE Portugal, SBTool^{PT}_Urban. The tool provides guidelines for evaluating the sustainability at the neighbourhood scale, in Portugal. In order to improve the intended framework, the study made a comparative analysis of the indicators of three main neighbourhood assessment tools relevant to sustainable urban development, iiSBE SNTool, BREEAM Communities, and LEED for Neighbourhood Development, with the pre-established indicators of iiSBE SBTool^{PT}-Urban as the case of this research. This comparison and analysis make it possible to identify the overlooked indicators and essential factors related to the sustainability of the urban neighbourhoods that due to their importance have the potential to be adapted by SBTool^{PT}-Urban, for the context of Portugal. These potential new indicators are evaluated to be aligned with EU Directives, as well. Besides, the alignment of the SBTool^{PT}-Urban´s indicators with the strategies promoted by Level(s), ISO 37120, and SDGs, are analysed. This result of this study can help to fill the gaps relevant with the sustainability issue covered by the tool, and to understand its alignment with the worldwide sustainability assessment criteria and standards. This can influence the monitoring and identification of problem areas regarding the sustainability issues, and facilitating sustainability comparisons over time in neighbourhood areas, in order to adapt new measurements and developing improvement strategies.

Keywords: urban sustainability assessment tools; urban sustainability indicators; neighbourhood sustainability; urban neighbourhoods; sustainable development.

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1. INTRODUCTION

Analysing how cities use natural resources and energy shows two of the most important aspects of the sustainability of urban public services and businesses. Local authorities and urban decision-makers have the opportunity to implement the improvements to reduce resource needs and environmental impacts. A vast body of literature is available to assess the sustainability of the built environment through multicriteria methods and tools. 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 (Steiniger, et al. 2020) to address social, economic, and environmental issues. Many organisations have prepared lists of indicators, such as the United Nations (2012), Paris Agreement (2015), ISO, and the International Initiative for a Sustainable Built Environment (iiSBE), which have resulted in a large dataset of urban sustainable indicators. These emerging sustainability initiatives, which at the beginning had been focused on micro-scale (building scale) developments, evolved later on in macro-scale (neighbourhood 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 environment (Sharifi & Murayama, 2013).

Furthermore, it is widely recognised that traditional urban planning models and approaches have contributed to the present environmental crisis (UN-HABITAT, 2010). It is clear that attaining sustainability requires addressing many fundamental issues at local, regional, and global levels, and achieving the goals and objectives of sustainability presents a great challenge for all segments of society (Gavrilescu, 2011). 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 figure out 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, as well as socio-economic inadequacies of neighbourhoods. These systems are developed through the indicators related to the identified criteria and harmonising systems inherited 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. Some of the internationally well-known systems for sustainability assessment of urban communities are BREEAM Communities (BREEAM-C), LEED for Neighbourhood Development (LEED-ND), CASBEE for Urban Development (CASBEE-UD), and Sustainable Neighbourhood Tool (SNTool) from iiSBE, etc. Urban sustainability is a broad concept consisting of many dimensions. Hundreds of indicators for urban sustainability and harmonised standards are established to describe the higher quality of life in urban areas. However, the current profusion of sustainable building and neighbourhood assessment systems, cannot lead to the built environment's long-term sustainability. Therefore, generating a concise and comprehensive list of indicators is a considerable undertaking (Steiniger, et al. 2020) for mapping side effects and identifying commitments or conflicts in each area (Shen, et al. 2011). Considering similar observations, this study utilises a more holistic approach by making an effort to illustrate the most significant environmental, social and economic aspects to be translated into firm demands, providing clear sustainability targets for the planning process in every region.

In this regard, this research contributes to the improvement of the pre-established evaluation structure of the neighbourhoods by iiSBE Portugal, SBTool^{PT}_Urban, which provides guidelines for evolving the measuring sustainability at the neighbourhood scale, in Portugal. In order to improve the intended framework, the study analyses the mandatory and important indicators established by some of the internationally well-known systems for sustainability assessment of urban communities including Sustainable Neighbourhood Tool (SNTool) from iiSBE, BREEAM Communities (BREEAM-C), LEED for Neighbourhood Development (LEED-ND), and Level(s). This comparison and analysis make it possible to identify a set of indicators and essential factors related to the sustainability of the urban neighbourhoods, for adapting to the existing framework, SBTool^{PT}_Urban, for the context of Portugal. Besides this, the study has considered the international frameworks, SDGs, ISO 37120, and Level(s) as a foundation methodology to examine the importance of the aspects addressed in the tools. With this study, a new level of opportunities for classifying sustainability aspects interactions has emerged so that the new potential issues can be examined, weighted, and scored more systematically in the future.

So, the aim of this research is: to compare the indicators of SBTool^{PT}-Urban and other indicators of urban sustainability methods including the international Sustainable Neighbourhood Tool (SNTool) from iiSBE, BREEAM Communities (BREEAM-C), and LEED for Neighbourhood Development (LEED-ND); to check the alignment of the strategies promoted by SBToolPT-U method with SDGs, current goals of ISO (37120), and Level(s); to identify those indicators that can be integrated into the SBToolPT-U, based on their alignment with EU Directives, and global sustainability challenges. For this, the study first described about the sustainable assessment methods, and the specific ones that are chosen to be used during the comparative analysis, by the study. Then, the methods and materials that are used by the study is described. And, the next chapter developed to analyse each category of the SBTool^{PT}_Urban, comparing the existing indicators with the similar indicators of the selected tools, came up with seven new indicators that have the potential to be added to the SBToolPT_Urban indicator list. Besides, the study analysed the compatibility of the strategies of the tool, with the objectives of Level(s), as the strategies in an urban scale should be a reflection of the strategies of the building scale. And, as the last step the study provided the calculation methods of the potential new indicators and how they can be merged to the existing categories of SBToolPT-Urban.

2. STATE OF THE ART

2.1 Emergence of Sustainability Assessment methods

The evolution of sustainability assessment methods has come a long way so far since its initial stages, in response to the inherent relationship between the growing environmental crisis and global economic competition (Hezri, 2004). These methods are developed to address the environmental degradation issues, which emerged from economic growth consequences for the consumption of non-renewable resources and the production of waste and pollution (Wangel et al., 2016). Agenda 2030, which was the first practical measure for implementing sustainable development), resulted from the 2012 UN Conference on Sustainable Development (UNCSD, or Rio+20), to negotiate the Sustainable Development Goals (SDGs). Agenda 2030 includes 17 SDGs, which encompass 231 unique indicators, to build a more sustainable, safer, and more prosperous planet for all of humanity. The agenda for the Paris Climate Conference in 2015 matches the SDGs, which provided common standards and achievable targets to reduce carbon emissions, manage the risks of climate change and natural disasters, and limit global warming to well below 2°C (UNDP). In conjunction with the Paris Climate agreement, Goal 13 of the 2030 Agenda calls for urgent action to combat climate change and its impacts. In addition, ISO focused on many other subjects in the environmental field, covering a vast range of standards, including Air Quality, Water Quality, Soil Quality, Environ-mental Management, Renewable Energy, etc. Besides these numerous initiatives in policy, planning, and standards, different groups of researchers and policymakers developed a growing set of principles for sustainable urban. These efforts are intended to reduce the built environment's carbon footprint and environmental impact, considering social issues such as thermal comfort, ease, and convenience (Berardi, 2013). Ultimately, these principles, which subsequently were grouped into specific categories, helped to address the sustainability of a building or neighbourhood. Currently, over 20 third-party assessment tools have emerged in various regions of the world, evolving to be more localised and focusing on being context-specific (Kaur & Garg, 2019).

2.2. Importance of sustainability indicators to shape the development of sustainable cities

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, 2019).(why SDGs are important) This allows for the practical implementation of the agenda 2030 goals. A sustainability assessment tool is perceived as 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, useful for monitoring changes in system characteristics relevant to the continuation of human and ecological well-being (Balaras et al., 2018). Overall, indicators are primarily "data carriers", measuring entities whose identity exclusively relies on the variables and parameters with which they are associated, independently from the context, purpose, and logic behind their use (Balaras et al., 2020). However, one single issue can be assessed by various indicators, addressing a variety of aspects (CESBA MED, 2019). Thus, it is essential to develop the necessary indicators considering the characteristics that define sustainable neighbourhoods to validate the sustainability strategies to be followed.

2.3. Definition and characteristics of sustainable neighbourhoods

The concept of a neighbourhood is a morphological and structural unit identified by a specific urban landscape, a certain social content, and different functions (Pires et al., 2014). At the same time, the characteristics of neighbourhoods involve a variety of components, such as space, form, building type, uses, activities, inhabitants, quality, level of maintenance, topography, symbols, etc. CESBA MED (Quinn et al., 2017) recommends defining the size of a neighbourhood as a square with 200 - 800 m, which can be crossed in a 10 - 15 min walk and has from 200 to 1,500 inhabitants. The basis of new urban areas is based on mixed uses developments, including a variety of types and costs for homes, 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 the basis for sustainable neighbourhoods. The integration of sustainability principles in neighbourhood design is essential because many of the problems encountered at the macro-city scale are cumulative consequences of poor planning at the micro-neighbourhood level. As for Engel-Yan (2005), sustainable neighbourhood design requires a well-developed understanding of these interactions as micro-level objectives are often limited by macro-scale conditions. The author described how a neighbourhood scale analysis could help develop more efficient and sustainable local urban infrastructure, including building, transportation, urban vegetation, and water systems (e.g., water supply, wastewater, and stormwater). Therefore, sustainable neighbourhoods are essential parts of a sustainable city (Sharifi & Murayama, 2013).

2.3.1 the most important issues for sustainable development

Based on the studied tools, the most prominent environmental, social, and economic issues that are closely linked with the most commending sustainability indicators of the selected tools demonstrated as:

- Preserving natural resources, in which renewable resources use as an alternative to non-renewable ones, reuse of materials and maintaining ecosystems and landscapes, as well as reuse the lands and considering the land use based on its potential,
- Energy consumption, in which renewable energy resources are used as a substitute for non-renewable energy resources,
- Urban planning strategies, in which density, urban structure and form, quality outdoor environment, efficient connectivity and public transportation services, and quality public spaces are all advocated in urban planning initiatives, and adaption to climate change is promoted,
- Value creation is stimulated by improving the local economy, health and living conditions driven by the provision of basic services, as well as by appreciating cultural identity.

2.4. Defining the selected sustainability assessment methods for urban neighbourhoods

2.4.1 iiSBE International Initiatives for a Sustainable Built Environment

iiSBE is an international non-profit organization whose overall aim was to actively facilitate and promote the adoption of policies, methods, and tools to accelerate the movement toward a global sustainable built environment. They are well known for the development of SBTool and SNTool, which are sophisticated but flexible building and urban performance assessment systems, that provide an understanding of neighbourhood performance issues and their interaction with the environment. The tools provided by iiSBE have taken a very different approach, by providing an open framework in which authorized regional users allow easy insertion of local languages and criteria, in an integrated way.

Accordingly, SBTool^{PT}_Urban (2018) is a methodology established and promoted by the iiSBE Portugal association. The assessment is carried out through the quantification of several indicators, organized according to different categories for assessing the sustainability of urban areas. The categories constitute the aspects, which considered most important in the assessment of environmental, social, and economic issues. This tool has a list of 14 categories, and 41 indicators, based on 49 parameters, as shown in Table 1. The categories are: Urban Form, Land Use and Infrastructure, Ecology and Biodiversity, Energy, Water, Materials and wastes, Outdoor comfort, Security, Amenities, Mobility, Local and Cultural Identity, Employment and Economic Development, Building, and Environment.

In 2020, another new transnational multicriteria assessment system for rating the sustainability of the built environment is developed within the European projects, known as CESBA med, an initiative of the iiSBE Italy, promoting SNTool. However, already many EU projects addressed environmental issues, proposing different methodologies, tools, and indicators, but CESBA was introduced as a collective bottom-up initiative that provides knowledge on harmonized assessment systems in the whole life cycle of the built environment. They have claimed to facilitate the adoption of assessment tools in policies and increase the number of certified buildings (CESBA guide, 2021). The SNTool, which is a framework at the urban scale, has developed seven sustainability issues with 23 categories, adaptable to the local context by selecting the indicators, based on the local priorities and issues. The issues are: Context and vulnerabilities, Built Urban Systems, Economy, Energy, Non-Renewable Resources, Environment, and Social Aspects. The tool includes two versions; the maximum version has 160 potentially active criteria, and the minimum version has currently 34 criteria (Larsson, 2019), shown in Table 2. For this study, we will develop our objectives through the generic framework of the minimum version of SNTool, which is based on the selection of the most important indicators.

Table 1. Dimensions, categories, and the indicators of SBTool^{PT}-Urban.

SBTool ^{PT} Urban (2018)		
Dimension	**Category**	**Indicator**
Environmental	1- Urban Form	1 -Passive Solar Planning
		2 -Ventilation potential
		3 - Urban Network
	2- Land Use and Infrastructure	4 - Natural Land Potential
		5 - Uses Density and Flexibility
		6 - Reuse of Urban Soil
		7 - Building Reuse
		8 - Technical Infrastructure Network
	3- Ecology and Biodiversity	9 - Distribution of Green Spaces
		10 - Connectivity of Green Spaces
		11 - Native Vegetation
		12 - Environmental Monitoring
	4- Energy	13 - Energy Efficiency
		14 - Renewable Energies
		15 - Centralized Energy Management

Table 1 (continued).

SBTool ^{PT} Urban (2018)		
Dimension	**Category**	**Indicator**
Environmental	5- Water	16 - Efficient Drinking Water Consumption
		17 - Effluent Management
		18 - Centralized Water Management
	6- Materials and wastes	19 - Low Impact Materials
		20 - Construction and Demolition Waste
		21 - Urban Solid Waste Management
Social	7 - Outdoor comfort	22 - Air Quality
		23 - Outdoor Thermal Comfort
		24 - Acoustic Pollution
		25 - Light Pollution
	8 - Security	26 - Street Safety
		27 - Natural and Technological Risks
	9 - Amenities	28 - Proximity to Services
		29 - Leisure Equipment
		30 - Local Food Production
	10 - Mobility	31 - Public Transport
		32 - Pedestrian Accessibility
		33 - Cycle Path Network
	11 – Local and Cultural Identity	34 - Public Spaces
		35 - Valuing Heritage
		36 - Social Inclusion and Integration
Economical	12 - Employment and Economic Development	37 - Economic Viability
		38 - Local Economy
		39 - Employability
Extra criteria - Complementary evaluation	13 - Buildings	40 - Sustainable Buildings
	14 - Environmental	41 - Environmental Management

Table 2. Dimensions, categories, and the indicators of SNTool.

Dimension	Category	Indicator
A Context and vulnerabilities	A1 Context and vulnerabilities	A1.1 Predicted change in regional ambient summer temperatures.
	A2 Vulnerability to flooding events	A2.2 Maximum percent buildings exposed to major damage from fluvial flooding events.
	A3 Vulnerability to windstorm events	A3.1 Buildings subject to major damage from windstorm events.
	A6 Vulnerability to earthquakes	A6.1 Buildings subject to major damage from earthquakes.
B Built Urban Systems	B1 Urban Structure and Form	B1.4 Residential density
		B1.7 Urban diversity
		B1.8 Conservation of Land
	B2 Transportation Infrastructure	B2.1 Walking distance to public transport for area residents.
		B2.2 Walking distance to public transport for area workers and students.

Table 2 (continued).

Dimension	Category	Indicator
B Built Urban Systems	B2 Transportation Infrastructure	B2.2 Walking distance to public transport for area workers and students.
		B2.4 Extent and connectivity of bicycle paths separated from vehicular traffic.
		B2.6 On-street and indoor car parking spaces relative to local population
	B3 Other local infrastructure	B3.2 Availability and access to a public sewage disposal and treatment system.
		B3.4 Availability and access to a public telecommunications system.
		B3.5 Availability and access to renewable energy infrastructure.
C Economy	C1 Economic Structure and Value	C1.2 Affordability of housing rental
	C3 Cost and Investment	C3.1 Provision for social housing units.
		C3.3 Operating energy costs for public buildings.
D Energy	D1 Non-renewable energy, aggregated	D1.7 Primary energy demand for heating of residential buildings.
		D1.10 Primary energy demand for cooling of non-residential buildings.
		D1.11 Primary energy demand for DHW in residential buildings.
	D2 Renewable and Decarbonized energy	D2.1 Share of renewable energy generated on-site, relative to total final energy consumption for operation of all buildings.
		D2.4 Share of renewable energy generated on-site, relative to total primary energy consumption for operation of all buildings.
		D2.7 Share of renewable energy generated in the local area, relative to the total final electric energy consumption.
E Non-Renewable Resources	E1 Potable water, stormwater and greywater	E1.5 Consumption of potable water by residential households
	E3 Resource consumption, reuse and maintenance	E3.1 Consumption of materials for non-renewable material resources for construction or renovation of buildings.
		E3.3 Percent of reused or recycled materials used for construction or renovation.
F Environment	F2 Environmental impacts	F2.5 Heat Island Effect in the local area.
	F3 Outdoor environmental quality	F3.1 Ambient air quality - ozone
		F3.11 Ambient night-time noise conditions.
	F4 Atmospheric emissions	F4.1 GHG emissions from energy embodied in construction materials used for construction, maintenance or replacement(s).
		F4.2 Aggregate GHG Emissions from primary energy used in building operations
		F4.5 Aggregate annual GHG emissions from the use of private vehicles.

Table 2 (continued).

Dimension	Category	Indicator
G Social Aspects	G1 Safety and Accessibility	G1.1 Accessibility and usability of key buildings by physically disabled persons.
		G1.4 Ease of access to and use of public transport for physically disabled persons.
	G2 Traffic and Mobility Services	G2.1 Access to a public transport service.
		G2.4 Quality of pedestrian and bicycle network.
	G4 Public and private facilities and services	G4.1 Proximity of key local consumer services to residential occupancies.
		G4.2 Availability of a diverse range of retail goods and services in the local area.
		G4.3 Availability and proximity of key local public services

2.4.2. BREEAM-C and LEED-ND

Among the existing sustainability assessment methods, the Building Research Establishment's Environmental Assessment Method (BREEAM) developed in the United Kingdom in 1990, is the first and leading sustainability assessment method. And, Leadership in Energy and Environmental Design (LEED) developed in the United States in 1998, grew fast and is nearly the dominant building assessment system around the world. LEED has been implemented in 41 countries, including Canada, Brazil, Mexico, India, and China.

BREEAM Community (BREEAM-C) sustainability assessment method has 5 main categories and 40 criteria and depending on the type of the project and certification schemes these criteria can be different or even some of them might not be considered. However, mandatory minimum performance standards are set for some of the categories, which they must be met, whatever Code level is sought. The five main categories, as shown in Table 3, are: Governance, Social and economic wellbeing, Resources and energy, Land use and ecology, Transport, and movement. And, in the LEED for Neighbourhood Development (LEED-ND) rating system the major prerequisites and credits are categorized in 5 main categories and 56 different criteria, illustrated in Table 4. It guarantees minimum levels of sustainable practice through mandatory measures in different credit categories and there are no points for meeting the mandatory minimum requirements. The five main categories are: Smart Location and Linkage (SLL), Neighbourhood Pattern and Design (NPD), Green Infrastructure and Buildings (GIB), Innovation (IN), Regional Priority (RP).

Table 3. Category aims, and the indicators of BREEAM Communities (2012).

Category		**Indicators**
Governance	Promotes community involvement in decisions affecting the design, construction, operation, and long-term stewardship of the development.	GO 01 - Consultation plan GO 02 - Consultation and engagement GO 03 - Design review GO 04 - Community management of facilities

Table 3 (continued).

Category		Indicators
Social and economic wellbeing	Local economy impact	SE 01 - Economic SE 17 - Training and skills
	Social wellbeing	SE 02 - Demographic needs and priorities SE 05 - Housing provision SE 06 - Delivery of services, facilities and amenities SE 07 - Public realm SE 09 – Utilities SE 11 - Green infrastructure SE 12 - Local parking SE 14 - Local vernacular SE 15 - Inclusive design
	Environmental conditions	SE 03 - Flood risk assessment SE 04 - Noise pollution SE 08 – Microclimate SE 10 - Adapting to climate change SE 13 - Flood risk management SE 16 - Light pollution
Resource and energy	Addresses the sustainable use of natural resources and the reduction of carbon emissions.	RE 01 - Energy strategy RE 02 - Existing buildings and infrastructure RE 03 - Water strategy RE 04 - Sustainable buildings RE 05 - Low impact materials RE 06 - Resource efficiency RE 07 - Transport carbon emissions
Land use and ecology	Encourages sustainable land use and ecological enhancement.	LE 01 - Ecology strategy LE 02 - Land use LE 03 - Water pollution LE 04 - Enhancement of ecological value LE 05 - Landscape LE 06 - Rainwater harvesting
Transport and movement	Addresses the design and provision of transport and movement infrastructure to encourage the use of sustainable modes of transport.	TM 01 - Transport assessment TM 02 - Safe and appealing streets TM 03 - Cycling network TM 04 - Access to public transport TM 05 - Cycling facilities TM 06 - Public transport facilities

Table 4. Categories, and the indicators of LEED for Neighbourhood Development (2018).

Category		Indicators
Smart Location and Linkage (SLL)	Focuses on selection of sites that minimize the adverse environmental effects of new development and avoid contributing to sprawl and its consequences. Choosing a smart location can make a substantial difference.	- Smart Location - Imperiled Species and Ecological Communities - Wetland and Water Body Conservation - Agricultural Land Conservation - Floodplain Avoidance - Preferred Locations - Brownfield Remediation - Access to Quality Transit - Bicycle Facilities - Housing and Jobs Proximity - Steep Slope Protection - Site Design for Habitat or Wetland and Water Body Conservation

Table 4 (continued).

Category		Indicators
Smart Location and Linkage (SLL)		- Restoration of Habitat or Wetlands and Water Bodies - Long-Term Conservation Management of Habitat or Wetlands and Water Bodies
Neighborhood pattern and design (NPD)	Emphasizes the creation of compact, walkable, mixed-use neighborhoods with good connections to nearby communities. These vibrant neighborhoods provide many important benefits to residents, employees, and visitors and to the environment.	- Walkable Streets - Compact Development - Connected and Open Community - Walkable Streets - Compact Development - Mixed-Use Neighborhoods - Housing Types and Affordability - Reduced Parking Footprint - Connected and Open Community - Transit Facilities - Transportation Demand Management - Access to Civic & Public Space - Access to Recreation Facilities - Visitability and Universal Design - Community Outreach and Involvement - Local Food Production - Tree-Lined and Shaded Streetscapes - Neighborhood Schools
Green infrastructure and buildings (GIB)	Focuses on measures that can reduce the environmental consequences of the construction and operation of buildings and neighborhood infrastructure. In the U.S., buildings account for large shares of energy consumption and water use. Globally, construction consumes a major part of the stone, gravel, sand, and virgin wood used in the world. Sustainable building technologies reduce waste and use energy, water, and materials more efficiently than conventional building practices.	- Certified Green Building - Minimum Building Energy Performance - Indoor Water Use Reduction - Construction Activity Pollution Prevention - Certified Green Buildings - Optimize Building Energy Performance - Indoor Water Use Reduction - Outdoor Water Use Reduction - Building Reuse - Historic Resource Preservation and Adaptive Reuse - Minimized Site Disturbance - Rainwater Management - Heat Island Reduction - Solar Orientation - Renewable Energy Production - District Heating and Cooling - Infrastructure Energy Efficiency - Wastewater Management - Recycled and Reused Infrastructure - Solid Waste Management - Light Pollution Reduction
Innovation (IN)	To recognize projects for innovative planning practices and sustainable building features.	- Innovation - LEED Accredited Professional
Regional Priority (RP)	Encourage project teams to focus on their local environmental priorities.	- Regional Priority Credit: Region Defined

2.4.3. Level(s)

Level(s) is the EU initiative that joins up sustainable "building" thinking across the Europe by offering guidance on the key areas of sustainability in the built environment and how to measure them during design and after completion. Level(s) is not a building certification scheme, as it doesn't set benchmarks and is more of a set of tools to help developing the aspects of sustainability. It is based on six overarching macro-objectives. The primary objective of Level(s) is to help construction and real estate stakeholders to reduce the environmental impacts of the buildings they invest in. This is why the European Commission has developed Level(s); a voluntary reporting framework to improve the sustainability of buildings. Level(s) provides a set of common indicators and metrics for measuring the environmental performance of buildings, which takes into account their full 'life-cycle'. It focuses attention on six key areas: greenhouse gas emissions, resource efficiency, water use, health and comfort, resilience and adaptation, and cost and value, as shown in Table 5. Level(s) holistic approach and incorporation of life cycle thinking is key to contributing to long-term goals such as Circular Economy, while supporting national initiatives. However, this supporting guide is developed for the building scale, creating a common language around sustainable buildings, but the strategies promoted by Level(s) can help for evaluation of the strategies implemented in a neighbourhood level, as well.

Table 5. Categories, and the indicators of Level(s).

Categories		**Indicators**
1. Greenhouse gas emissions along a building's life cycle	Minimize the whole life carbon output, consider both energy consumption during the use phase of the building and embodied energy.	1.1 Use stage energy performance (kWh/m2/yr)
		1.2 Life cycle Global Warming Potential (CO2 eq./m2/yr)
2. Resource efficient and circular material life cycles	Optimize the building design to support lean and circular flows, including: Building materials use and quantities, Minimize construction and demolition waste generated to optimize material use, Replacement cycles and flexibility to adapt to change, Potential for deconstruction as opposed to demolition.	2.1 Bill of quantities, materials, and lifespans
		2.2 Construction & Demolition waste and materials
		2.3 Design for adaptability and renovation
		2.4 Design for deconstruction, reuse and recycling
3. Efficient use of water resources	Use water efficiently, particularly in areas of identified long-term or projected water stress.	3.1 Use stage water consumption (m3/occupant/yr)
4. Healthy and comfortable spaces	Create buildings that are comfortable, attractive, and productive. This includes four aspects of the quality of the indoor environmental quality: The indoor air for specific parameters and pollutants, The degree of thermal comfort, The quality of artificial and natural light and associated visual comfort, The capacity of the building fabric to insulate occupiers from internal and external sources of noise.	4.1 Indoor air quality
		4.2 Time outside of thermal comfort range
		4.3 Lighting and visual comfort
		4.4 Acoustics and protection against noise

Table 5 (continued).

Categories		Indicators
5. Adaption and resilience to climate change	Futureproof building performance: Adapt to changes of future climate impacting on thermal comfort, Make the building more resilient and resistant to extreme weather events (including flooding: fluvial, pluvial and coastal), Improve the building design to reduce the chances of pluvial/fluvial flood events in the local area (i.e., increasing sustainable drainage).	5.1 Protection of occupier health and thermal comfort
		5.2 Increased risk of extreme weather
		5.3 Sustainable drainage
6. Optimized life cycle cost and value	Long term view of the whole life costs and market value of more sustainable buildings, including: Life cycle costs (construction, operation, maintenance, refurbishment and disposal), Encourage the integration of sustainability aspects into market value assessment and risk rating processes and ensure that this is done as informed and transparent as possible.	6.1 Life cycle costs (€/m²/yr)
		6.2 Value creation and risk factors

2.4.4 ISO 37120, for Sustainable Cities and Communities

ISO 37120 standard was published for the first time in 2014 and it specified 19 main categories, 46 Core indicators, and 54 Supporting and 35 profile indicators that provide a uniform approach to what is measured, and how that measurement is to be undertaken. In 2018, 28 new indicators were updated and added, removal of 24 old ones and slight modification to 10 indicators performed, as shown in Table 7.

ISO standards are internationally agreed upon by experts, covering a huge range of activities, such as quality management standards, environmental management standards, health and safety standards, energy management standards, food safety standards, etc. The ISO strategy for 2030 is aligned with the United Nations' global agenda for 2030. ISO 37120 for Sustainable Cities and Communities is a set of standards including the indicators for city services and quality of life. It includes 104 key performance indicators across 19 categories (themes). The categories are including economy, housing, education, energy, recreation, environment and climate change, safety, finance, solid waste, governance, sport and culture, health, telecommunication, population and social conditions, transportation, urban/local agriculture, and food security, urban planning, wastewater, and water. These indicators are designed to track and monitor progress on city performance. Therefore, the alignment of the main issues of urban sustainability assessment tools with the strategies followed by ISO 37120 can help to achieve sustainable development.

2.4.5 SDGs, Sustainable development goals

The SDGs build on decades of work by countries and the UN and constitute a combined goal and issue-oriented framework that forms the core of the United Nations' 2030 Agenda for Sustainable Development (UN, 2015). Agenda 2030 consists of a list of 17 Sustainable Development Goals (SDGs), each covering a thematic area, and 169 targets, which the subscribing national governments are committed to pursuing. It has addressed: People (broadly corresponding to Goals 1-5), Planet (6, 12, 13, 14 and 15), Prosperity (7-11), Peace (16), and Partnership (17), defined as the 5Ps. According to CESBA Alps (2017), once countries have decided on their national targets, they will need to decide on how to implement policy strategies to achieve those goals, and how to track progress in their implementation plans. Therefore, to make the 2030 Agenda, a reality, broad ownership of the SDGs must translate into a strong commitment by all stakeholders to implement the global goals (UN). In this research, the alignment of the indicators of SBTool^{PT}-Urban with the SDGs are analysed.

2.4.6 Overview of sustainability assessment methods

Building environmental assessment methods are considered one of the most potent and effective means to improve the performance of the built environment (Lockwood, 2006). Despite a relatively short history, building and urban environmental assessment methods have attracted the attention and interest of the academia (Appu, 2012). Also, due to the fact that existing assessment tools may not always be able to objectively or accurately reflect the level of sustainability, the refining and evolving of assessment items is necessary (Kim et al. 2013). Thus, most of these assessment tools would evolve with time, incorporating the latest technologies, regulations, and experience in practice (Li et al., 2017). For example, the pilot version LEED (LEED 1.0) for new construction was first launched in August 1998 (Lee & Burnett, 2008) and continued to lease LEED-NC Version 4.0 2013 (USGBC). Other sustainability assessment methods, such as BREEAM, BEAM Plus, and Green Mark, were renewed nearly every three years to provide reliable sustainable evaluations and certification systems (Li et al., 2017). There are different ways to refine existing assessment methods by analysing their strengths and weaknesses such as: feedback information obtained from sustainable buildings professionals (Hamilton et al., 2013), and comparisons of existing assessment methods, especially highly recognized ones. Amongst them, the comparative analysis approach is most commonly used to derive useful, reachable, and reliable sustainability insights within a short period of time (Shamseldin, 2018). In this study, a comparative analysis concerning the developed aspects of sustainability between the selected tools is conducted that can identify the gaps of the developed factors and aspects for the existing assessment methods, with specific attention for SBTool^{PT}-Urban, and shed light on the trends for future improvement or development.

2.6. Problem statement

Although, many of the sustainability assessment methods are widely accepted due to their high recognition, but defining new assessment aspects and factors, concerning the new challenges of the constantly evolving nature of sustainability, is important (Kim & Kim, 2013). SBTool^{PT}-Urban method established in 2018. Therefore, to evolve the capabilities of the tool regarding the emerging new initiatives, indicators, and latest standards for the sustainability of urban regions, the refining and evolving of the assessment factors is a necessity. This can result to assure that the assessment tool reflects the relevant issue of sustainability objectively and accurately and identifying if there is lack of up-to-date and reliable measuring factors.

Key Question: The question that the research sought to answer is; what the other indicators and priorities are can be adapted to the SBTool^{PT}_Urban, to be in line with the current trends and developments?

2.7. Study objectives

This research aims to identify the accuracy of the current version of the SBTool^{PT}-Urban, in terms of the issues and aspects relevant with sustainable urban performance. For this, the study developed a broad comparison analyse of a series of indicators provided by the selected well-known tools. Accordingly, the main objectives of this study are as follows:

- To compare the indicators of SBTool^{PT}-Urban and other indicators of urban sustainability methods including the international Sustainable Neighbourhood Tool (SNTool) from iiSBE, BREEAM Communities (BREEAM-C), and LEED for Neighbourhood Development (LEED-ND),
- To check the alignment of the strategies promoted by SBTool^{PT}-U method with SDGs, current goals of ISO (37120), and Level(s).
- To identify those indicators that can be integrated into the SBTool^{PT}-U, based on their alignment with EU Directives, and global sustainability challenges.

3. MATERIALS AND METHODS

3.1 Approach

This study seeks to investigate the indicators of urban sustainability assessment methods, by comparison of different assessment systems, to identify the key similarities and differences and consequently establish the essential sustainable criteria for potential consolidation adjustment in SBTool^{PT}-Urban method. SBTool^{PT}_Urban (2018) is a sustainability assessment method promoted by the iiSBE Portugal association. The assessment method is carried out for assessing the sustainability of urban areas. The method is based on the several categories constitute the aspects, which considered most important in the assessment of environmental, social, and economic issues. This tool has a list of 14 categories, and 41 indicators, as shown in Table 6.

The proposed methodology is based on the requirements and needs of sustainability assessment methods for updating. Indicator comparison is the most detailed comparison and is conducted in 33% of the selected papers (Li et al., 2017). Since there are many variables used in each method, it is also unlikely to compare the entire variables. Instead, comparison in this study focused on aspects and issues, based on the present 14 categories of SBTool^{PT}-Urban. It provides issues and aspects that have the potentials to be adapt to the former list of indicators, to be followed and framed within the evaluation system. A comparison between the total present 522 indicators of the methods is given to illustrate the priorities. Considering the suitability for Portugal, based on the EU Directives alignment, identifying the possibilities and potentialities of adaptation from the list of indicators to SBTool^{PT}-U.

3.2 Procedures

The first step of the implemented methodology is to identify the Sustainable Assessment Methods of neighbourhoods most recognised in the market and their potential to support the decision making. For this, several assessment methods were identified and studied in the literature review. Three final methods selected according to their criteria, including a clear and comprehensive basis on sustainability, recent activity, urban scale, and availability of the indicators. These sustainability schemes are: BREEAM-C and LEED-ND are the leading systems; both being operated by well-known organisations (BRE and USGBC) that have a proven record in the domain of sustainability development, and also iiSBE SNTool is a system designed to permit local government and NGO officials to undertake an assessment of the sustainability performance of urban neighbourhoods. On the other hand, SBTool^{PT}-Urban is a case of Method, which developed specifically for Portuguese urban scale, considering the national context. Also, three other tools that internationally use as frameworks that provide a common language for sustainability performance of neighbourhoods, including Level(s), ISO 37120, and SDGs. The primary source of information used to analyse the selected tools was the technical manual of each tool.

3.3 Research method and definition

In this topic, SBTool^{PT}-Urban among the other selected methods and international goals and regulation, will be analysed. The existing sustainability concerns will also be identified. So, this task aims to establish a list of criteria for neighbourhoods, where it will be defined in the framework of SBTool^{PT}-Urban method. The objective is to adapt new potential indicators for the present list of indicators of SBTool^{PT}-Urban method, for the Portugal context, measurable and associated with the goals of Sustainable Development, ISO 37120, and Level(s). Within this framework, a new proposal includes a broader and comprehensive list of indicators and factors to support urban stakeholders in the creation of a more sustainable neighbourhoods' establishment and also factors that can be added to the existing indicators identified.

3.4 Data collection

The categories can be defined as labelled groups of sustainability issues that can be evaluated and given credits, points, or qualitative judgments. In this research, different indicators of the selected tools are recategorized based on the category framework of SBTool^{PT}-Urban. For this, after screening of the established indicators of the tools, the study rearranged the most relevant indicators according to their issues, to the most pertinent categories. In the next step, the study performed a comparative analysis of the indicators of each category, shown in Tables 9-34, to identify the important indicators, which are neglected in the existing list of the case study tool. The study analysis focused on revealing what sustainability aspects are the most commending in the tools, and the aspects, which are omitted. Also, additional motivation was gained by identifying that there are similar issues, which dealt with within the different tools. The frequency of the indicators with similar issues and objectives, provided by different tools, which categorised in the common titles, are depicted in Figure 2-14. Some indicators assess on issue of sustainability, and some other indicators assess more than one issue. Either the indicator contained the assessment of more than one sustainability factor, or assigned only for assessment of one factor, in both cases the study considered one point for each of them, in the charts (Figure 2-14). In addition, if the indicators are aligned with the indicators of ISO 37120, and SDGs of Agenda 2030, apart from the number of indicators, the study assigned only one point for them.

To extract the required data, an excel sheet with selected tools on the columns, and rows for collecting indicators on a wide range of issues, including titles of the categories of the tools, the promoted indicators, and the aspects or objectives, for assessing the sustainability issues in a quantitative or qualitative approach, which developed by the tools was implemented.

3.5 Hierarchical Analysis

The methodology for analysing the priorities and decisions is checking the consistency of the present and potential new indicators with the international methods and targets, developed for sustainability of neighbourhood's areas. The following five steps is developed to make a decision in an organised way to find priorities of the objects:

1. Categorising indicators, defining their goals,
2. Creating a set of comparative analysis. Each indicator which represents the issue relative to the present indicators of SBTool^{PT}-Urban got the code of that indicator,
3. The indicators which are not within the present indicators of SBTool^{PT}-Urban, obtained from the comparisons, considered as a new factor,
4. the inclusion of the indicators within the list of the issues which promoted by ISO 37120 and SDGs is considered as an approval for being aligned with the international strategies and targets,

5. if the new indicator/factor is defined by the EU priorities, and/or there are enough logics for its importance, it considered for selecting in the final list of indicators.

In addition, the indicators which were chosen for the final list, provided by the calculation methods, and/or the specifications that should be included for their qualitative assessment. The number of credits belonging to each issue and the value of the weighted credits, is not within the objectives of this study.

The flowchart in Figure 1 describes the process that were used to filter and screen the different indicators and analysis the alignment with the global strategies.

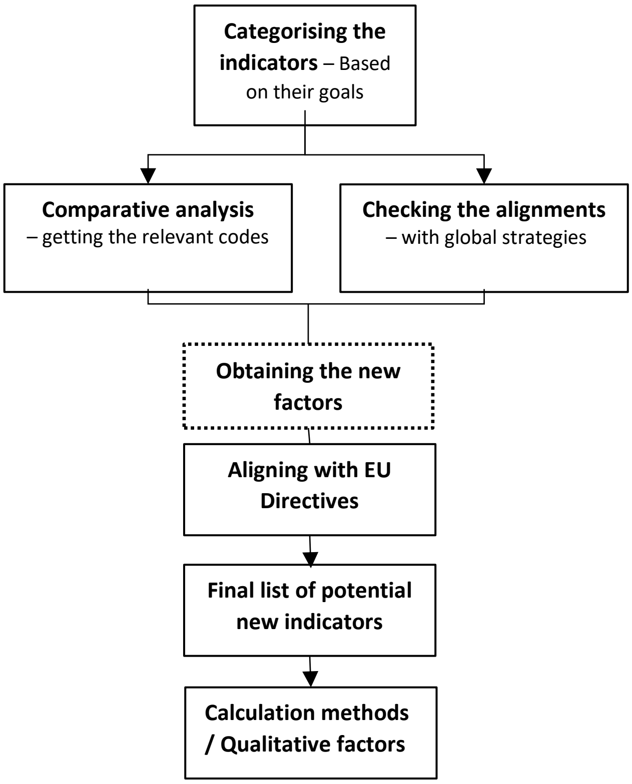


Figure 1. The process of filtering and screening the different indicators and analysing the alignment with the global strategies.

4. RESULTS AND DISCUSSION

4.1 Analysing the Compatibility of the Strategies of SBTool^{PT}_Urban with the Objectives of Level(s)

As the developed strategies in an urban scale should be a reflection of the promoted strategies in the building scale, the study analyses the alignment of the categories and indicators of SBToolPT_Urban, with the macro-objectives and core indicators of Level(s), which offers an extensively tested system for assessing and reporting on the sustainability performance of buildings. The Level(s) framework is structured around six categories or 'macro-objectives', identified by the European Commission. Its indicators contribute to achieving these macro-objectives, as shown in Table 5. Further details on these indicators can be found in the comparison analysis of the categories (Tables 10, 12, 14, 15, 17, 18, 20, 22, 24, 26, 28, 30, 32, 34), shown in the next sections. Level(s) offers an extensively tested system for assessing and reporting on the sustainability performance of buildings. It has a clear set of prioritised performance indicators for six areas of sustainability (named macro-objectives), contributing to EU policy goals, to measure carbon, materials, water, health, comfort, and climate change impacts throughout a building's full life cycle. Its holistic approach and incorporation of life cycle thinking is key to contributing to long-term goals such as Circular Economy, while supporting national initiatives. However, this supporting guide is developed for the building scale, creating a common language around sustainable buildings, but the strategies promoted by Level(s) can help for evaluation of the strategies implemented in a neighbourhood level, as well.

Therefore, the study evaluated in detail the compatibility of the indicators of SBTool^{PT}-Urban with the core indicators of Level(s), as shown in Tables 9-34. Moreover, the compatibility of the Macro objectives of Level(s) with the categories of SBTool^{PT}-Urban are analysed, as can be seen in Table 6. The findings of the research reveal that the Macro objectives of Level(s) have compatibility with, at least, one category of SBTool^{PT}-Urban, which reveals that the tool is aligned with the strategies promoted by level(s).

Table 6. Compatibility of the objectives of Level(s) issues and purposes with the categories of SBTool^{PT}-Urban.

Categories of Level(s)	Indicators of Level(s)	Categories of SBTool^{PT}-Urban
1. Greenhouse gas emissions along a building's life cycle	1.1 Use stage energy performance (kWh/m2/yr)	Category 4 - Energy
	1.2 Life cycle Global Warming Potential (CO2 eq./m2/yr)	Category 6 - Material and waste
2. Resource efficient and circular material life cycles	2.1 Bill of quantities, materials, and lifespans	Category 6 - Material and waste
	2.2 Construction & Demolition waste and materials	
	2.3 Design for adaptability and renovation	
	2.4 Design for deconstruction, reuse and recycling	
3. Efficient use of water resources	3.1 Use stage water consumption (m3/occupant/yr)	Category 5 - Water
4. Healthy and comfortable spaces	4.1 Indoor air quality	Category 7 - Outdoor comfort
	4.2 Time outside of thermal comfort range	
	4.3 Lighting and visual comfort	
	4.4 Acoustics and protection against noise	

Table 6 (continued).

Categories of Level(s)	Indicators of Level(s)	Categories of SBTool^{PT}-Urban
5. Adaption and resilience to climate change	5.1 Protection of occupier health and thermal comfort	Category 1 - Urban Form Category 7 - Outdoor comfort
	5.2 Increased risk of extreme weather	Category 7 - Outdoor comfort Category 8 - Security
	5.3 Sustainable drainage	Category 8 - Security
6. Optimized life cycle cost and value	6.1 Life cycle costs (€/m²/yr)	These costs will be strongly influenced by the decisions and calculated performance of the following categories: Category 4 - Energy Category 6 - Material and waste Category 5 - Water
	6.2 Value creation and risk factors	Category 12 - Employment and economic development

4.2 Analysing Compatibility with the Objectives of ISO 37120

At this level, the evaluation of SBTool^{PT}-Urban method is developed to recognise the commitment between the method and the objectives of ISO 37120 framework for sustainable development of communities. For this, the study provides a detail comparision between the indicators of SBTool^{PT}-Urban with the indicators of ISO 37120, to determine the alignment of the indicators. The study found that 28 indicators of SBTool^{PT}-Urban out of 41 are directly relevant with the indicators of ISO 37120. This is shown for each category in detail, in Annex 1-14. Also, to explore the strategies that promoted by ISO 37120 for sustainable communities, to be encompassed in SBTool^{PT}-Urban, a seperated comparision developed, shown in Annex 16. This comparision illustrated that for 15 categories (out of 19) of ISO 37120, the SBTool^{PT}-Urban has developed at least one relevant indicator. Another 4 other categories, including Population and social conditions, Health, Governance, and Education are practically out of the scopes of SBTool^{PT}-Urban. This is due to the developed indicators of these categories are for the city scale, but not a neighborhood scale, or relevant with social statistics and sociologycal issues. However, the main targets of them are within the domain of the strategies which are developed by SBTool^{PT}-Urban. Base on this, a comparision between the relevant categories of SBTool^{PT}-Urban and ISO 37120 is shown in Table 7. This comparision highlight how all aspects of sustainability are connected, especially including the direct connection of:

- Urban planning with: Urban Form (C1), Land use and Infrastructure (C2), Eecology and biodiversity (C3), Amenities (C9), Local and Cultural Identity (C11).
- Environment and climate change with: Eecology and biodiversity (C3), Outdoor comfort (C7).
- Recreation and Sport and culture with: Amenities (C9), Local and Cultural Identity (C11).

Also, this comparision echoes SBTool^{PT}-Urban's holistic approach to environmental assessment of communities.

Table 7. Exploring how the SBTool^{PT}-Urban suite of schemes align with the ISO 37120.

ISO 37120		SBTool^{PT}-Urban	
Categories	**Indicators**	**Indicators**	**Categories**
5 Economy	5.1 City's unemployment rate (core indicator)		**C 12 - Employment and economic development**
	5.2 Assessed value of commercial and industrial properties as a percentage of total assessed value of all properties (supporting indicator)	C12. I38. Local Economy	
	5.3 Percentage of city population living in poverty (core indicator)		
	5.4 Youth unemployment rate (supporting indicator)		
	5.5 Number of businesses per 100 000 population (supporting indicator)	C12. I39. Employability	
	5.6 Number of new patents per 100 000 population per year (supporting indicator)		
	5.7 Annual number of visitor stays (overnight) per 100 000 population (supporting indicator)		
	5.8 Commercial air connectivity (number of non-stop commercial air destinations) (supporting indicator)		
6 Education	6.1 Percentage of female school-aged population enrolled in schools (core indicator)		
	6.2 Percentage of students completing primary education: survival rate (core indicator)		
	6.3 Percentage of students completing secondary education: survival rate (core indicator)		
	6.4 Primary education student–teacher ratio (core indicator)		
	6.5 Percentage of male school-aged population enrolled in schools (supporting indicator)		
	6.5 Percentage of school-aged population enrolled in schools (supporting indicator)		
7 Energy	7.1 Total end-use energy consumption per capita (GJ/year) (core indicator)	C4. I13. Energy Efficiency	**C 4 - Energy**
	7.2 Percentage of total end-use energy derived from renewable sources (core indicator)	C4. I14. Renewable Energies	
	7.3 Percentage of city population with authorized electrical service (residential) (core indicator)		
	7.4 Number of gas distribution service connections per 100 000 population (residential) (core indicator)		
	7.5 Final energy consumption of public buildings per year (GJ/m2) (core indicator)	C4. I13. Energy Efficiency	
	7.6 Electricity consumption of public street lighting per kilometre of lighted street (kWh/year) (supporting indicator)		
	7.7 Average annual hours of electrical service interruptions per household (supporting indicator)		

Table 7 (continued).

ISO 37120		SBTool^{PT}-Urban	
Categories	**Indicators**	**Indicators**	**Categories**
8 Environment and climate change	8.1 Fine particulate matter (PM2.5) concentration (core indicator)	C7. I22. Air quality	**C 3 - Ecology and biodiversity** **C 7 - Outdoor comfort**
	8.2 Particulate matter (PM10) concentration (core indicator)		
	8.3 Greenhouse gas emissions measured in tonnes per capita (core indicator)		
	8.4 Percentage of areas designated for natural protection (supporting indicator)	C3. I11. Native Vegetation	
	8.5 NO2 (nitrogen dioxide) concentration (supporting indicator)	C7. I22. Air quality	
	8.6 SO2 (sulfur dioxide) concentration (supporting indicator)		
	8.7 O3 (ozone) concentration (supporting indicator)		
	8.8 Noise pollution (supporting indicator)	C7. I24. Acoustic Pollution	
	8.9 Percentage change in number of native species (supporting indicator)	C3. I11. Native Vegetation C3. I12. Environmental monitoring	
9 Finance	9.1 Debt service ratio (debt service expenditure as a percentage of a city's own-source revenue) (core indicator)		**C 12 - Employment and economic development**
	9.2 Capital spending as a percentage of total expenditures (core indicator)		
	9.3 Own-source revenue as a percentage of total revenues (supporting indicator)	C12. I39. Employability	
	9.4 Tax collected as a percentage of tax billed (supporting indicator)		
10 Governance	10.1 Women as a percentage of total elected to city-level office (core indicator)		-
	10.2 Number of convictions for corruption and/or bribery by city officials per 100 000 population (supporting indicator)		
	10.3 Number of registered voters as a percentage of the voting age population (supporting indicator)		
11 Health	11.1 Average life expectancy (core indicator)		-
	11.2 Number of in-patient hospital beds per 100 000 population (core indicator)		
	11.3 Number of physicians per 100 000 population (core indicator)		
	11.4 Under age five mortality per 1 000 live births (core indicator)		
	11.5 Number of nursing and midwifery personnel per 100 000 population (supporting indicator)		
	11.6 Suicide rate per 100 000 population (supporting indicator)		

Table 7 (continued).

ISO 37120		SBTool^{PT}-Urban	
Categories	**Indicators**	**Indicators**	**Categories**
12 Housing	12.1 Percentage of city population living in inadequate housing (core indicator)	C11. I36. Social inclusion and integration	**C 11 - Local and Cultural Identity**
	12.2 Percentage of population living in affordable housing (core indicator)		
	12.3 Number of homeless per 100 000 population (supporting indicator)		
	12.4 Percentage of households that exist without registered legal titles (supporting indicator)		
13 Population and social conditions	13.1 Percentage of city population living below the international poverty line (core indicator)		**-**
	13.2 Percentage of city population living below the national poverty line (supporting indicator)		
	13.3 Gini coefficient of inequality (supporting indicator)		
14 Recreation	14.1 Square metres of public indoor recreation space per capita (supporting indicator)		**C 9 - Amenities** **C 11 - Local and Cultural Identity**
	14.2 Square metres of public outdoor recreation space per capita (supporting indicator)	C9. I29. Recreational facilities C11. I34. Access to Public Spaces	
15 Safety	15.1 Number of firefighters per 100 000 population (core indicator)	C8. I27. Natural and technological risks	**C 8 - Security**
	15.2 Number of fire-related deaths per 100 000 population (core indicator)		
	15.3 Number of natural-hazard-related deaths per 100 000 population (core indicator)		
	15.4 Number of police officers per 100 000 population (core indicator)		
	15.5 Number of homicides per 100 000 population (core indicator)		
	15.6 Number of volunteer and part-time firefighters per 100 000 population (supporting indicator)		
	15.7 Response time for emergency response services from initial call (supporting indicator)	C8. I27. Natural and technological risks	
	15.8 Crimes against property per 100 000 population (supporting indicator)		
	15.9 Number of deaths caused by industrial accidents per 100 000 population (supporting indicator)		
	15.10 Number of violent crimes against women per 100 000 population (supporting indicator)		
16 Solid waste	16.1 Percentage of city population with regular solid waste collection (residential) (core indicator)	C6, I21 - Urban solid waste management	**C 6 - Material and waste**
	16.2 Total collected municipal solid waste per capita (core indicator)		
	16.3 Percentage of the city's solid waste that is recycled (core indicator)	C6, I20 - Construction and Demolition Waste	
	16.4 Percentage of the city's solid waste that is disposed of in a sanitary landfill (core indicator)	C6, I21 - Urban solid waste management	
	16.5 Percentage of the city's solid waste that is treated in energy-from-waste plants (core indicator)		

Table 7 (continued).

ISO 37120		SBTool^{PT}-Urban	
Categories	**Indicators**	**Indicators**	**Categories**
16 Solid waste	16.6 Percentage of the city's solid waste that is biologically treated and used as compost or biogas (supporting indicator)		
	16.7 Percentage of the city's solid waste that is disposed of in an open dump (supporting indicator)		
	16.8 Percentage of the city's solid waste that is disposed of by other means (supporting indicator)	C6, I20 - Construction and Demolition Waste	
	16.9 Hazardous waste generation per capita (tonnes) (supporting indicator)		
	16.10 Percentage of the city’s hazardous waste that is recycled (supporting indicator)		
17 Sport and culture	17.1 Number of cultural institutions and sporting facilities per 100 000 population (core indicator)	C9, I28 - Proximity to services	**C 9 – Amenities** **C 11 - Local and Cultural Identity**
	17.2 Percentage of municipal budget allocated to cultural and sporting facilities (supporting indicator)	C11, I34 - Access to Public Spaces	
	17.3 Annual number of cultural events per 100 000 population (e.g. exhibitions, festivals, concerts) (supporting indicator)	C11, I35 - Valuing Heritage	
18 Telecommunication	18.1 Number of internet connections per 100 000 population (supporting indicator)	C14. I41. Environmental Management	**C14 - Environment**
	18.2 Number of mobile phone connections per 100 000 population (supporting indicator)		
	17.3 Number of landline phone connections per 100 000 population (supporting indicator)		
19 Transportation	19.1 Kilometres of public transport system per 100 000 population (core indicator)	C10. I31. Public Transport	**C 10 - Mobility**
	19.2 Annual number of public transport trips per capita (core indicator)		
	19.3 Percentage of commuters using a travel mode to work other than a personal vehicle (supporting indicator)	C10. I32. Pedestrian Path Accessibility	
	19.4 Kilometres of bicycle paths and lanes per 100 000 population (supporting indicator)	C10. I33. Cycle Path Network	
	19.5 Transportation deaths per 100 000 population (supporting indicator)		
	19.6 Percentage of population living within 0,5 km of public transit running at least every 20 min during peak periods (supporting indicator)	C10. I31. Public Transport	
	19.7 Average commute time (supporting indicator)	C10. I32. Pedestrian Path Accessibility	
20 Urban/local agriculture and food security	20.1 Total urban agricultural area per 100 000 population (core indicator)	C9. I30. Local food production	**C 9 - Amenities**
	20.2 Amount of food produced locally as a percentage of total food supplied to the city (supporting indicator)		
	20.3 Percentage of city population undernourished (supporting indicator)		
	20.4 Percentage of city population that is overweight or obese — Body Mass Index (BMI) (supporting indicator)		

Table 7 (continued).

ISO 37120		SBToolPT-Urban	
Categories	**Indicators**	**Indicators**	**Categories**
21 Urban planning	21.1 Green area (hectares) per 100 000 population (core indicator)	C3. I9. Distribution of Green Spaces C9. I29. Recreational facilities C11. I34. Access to Public Spaces C11. I36. Social inclusion and integration	**C 1 - Urban Form** **C 2 - Land use and Infrastructure** **C 3 - Eecology and biodiversity** **C 9 – Amenities** **C 11 - Local and Cultural Identity**
21 Urban planning	21.2 A real size of informal settlements as a percentage of city area (supporting indicator)		
	21.3 Jobs–housing ratio (supporting indicator)	C11. I36. Social inclusion and integration	
	21.4 Basic service proximity (supporting indicator)	C9, I28 - Proximity to services	
	21.5 Urban planning profile indicators 21.5.1 Population density 21.5.2 Number of trees per 100 000 population 21.5.3 Built-up density	C1, I1 - Passive Solar Planning C1, I2 - Ventilation potential C2, I5 - Uses Density and Flexibility	
22 Wastewater	22.1 Percentage of city population served by wastewater collection (core indicator)	C5, I17 - Effluent Management	**C 5 - Water**
	22.2 Percentage of city's wastewater receiving centralized treatment (core indicator)	C5, I18 - Centralised Water Management	
	22.3 Percentage of population with access to improved sanitation (core indicator)		
	22.4 Compliance rate of wastewater treatment (supporting indicator)	C5, I17 - Effluent Management	
23 Water	23.1 Percentage of city population with potable water supply service (core indicator)	C5, I16 - Efficient Drinking Water Consumption	**C 5 - Water**
	23.2 Percentage of city population with sustainable access to an improved water source (core indicator)		
	23.3 Total domestic water consumption per capita (litres/day) (core indicator)		
	23.4 Compliance rate of drinking water quality (core indicator)		
	23.5 Total water consumption per capita (litres/day) (supporting indicator)		
	23.6 Average annual hours of water service interruptions per household (supporting indicator)		
	23.7 Percentage of water loss (unaccounted for water) (supporting indicator)		

4.3 Analysing the indicators of the selected tools

In this section, the study analysis 522 indicators of the selected tools, to find out the indicators with the potential to be added to the tool. The figures presented in the next sections indicated the frequency of the indicators covered by the analysed sustainability assessment methods and give an overview of the most and least popular indicators for each category. The alignment of the proposed potential new indicators with urban Sustainable Development Goals (SDGs) and ISO 37120 standards, and Level(s) are discussed. Moreover, the proposed indicators are studied to be prioritised by EU Directives. The study provides a narrative description of each category to provide the rationale for its significance and depicted the level of usability of the indicators through the charts, enabling the comparison of their frequencies among the studied tools. The study then determined which indicators can be added or discarded and provided the rationales. The existing list of indicators of SBTool^{PT}-U, and the identified indicators, which were not included in the existing list are shown in Table 8.

Table 8. Compliance of the tools with the indicators of SBTool^{PT}-Urban.

		SBTool^{PT}U	SNTool	BREEAMC	LEEDND	Levels	ISO	SDGs
Category 1 - Urban Form								
I1	Passive Solar Planning	1		2	1	✓	✓	✓
I2	Ventilation potential	1		2		✓	✓	✓
I3	Urban Network	1		2	1			✓
Category 2 - Land use and Infrastructure								
I4	Use Natural Potential of Land	1		1	2			✓
I5	Uses Density and Flexibility	1	2		3		✓	✓
I6	Reuse of Urban Land	1	1	1	1			✓
I7	Building Reuse	1		1	1			✓
I8	Technical Infrastructure Network	1						
New	Conservation of Land		1	1	1		✓	✓
Category 3 - Ecology and biodiversity								
I9	Distribution of green spaces	1					✓	✓
I10	Connectivity of green spaces	1						✓
I11	Native Vegetation	1		2	2		✓	✓
I12	Environmental monitoring	1		1	2		✓	✓
New	Construction activity pollution prevention				1			✓
Category 4 - Energy								
I13	Energy Efficiency (of public facilities)	1	1	1	1		✓	✓
I14	Renewable Energies	1	7	1	1	✓	✓	✓
I15	Centralized Energy Management	1		1				✓
New	District Heating and Cooling				1			
Category 5 - Water								
I16	Efficient Drinking Water Consumption	1	1	1	1	✓	✓	✓
I17	Effluent Management	1	1	1	2	✓	✓	✓
I18	Centralized Water Management	1					✓	✓
Category 6 - Material and waste								
I19	Low Impact Materials	1	1	1		✓		✓
I20	Construction and Demolition Waste	1	1	2	1	✓	✓	✓
I21	Urban solid waste management	1			1	✓	✓	✓

Table 8 (continued).

		SBTool^{PT}U	SNTool	BREEAMC	LEEDND	Levels	ISO	SDGs
Category 6 - Material and waste								
New	GHG emissions from energy embodied in construction materials		1			✓	✓	✓
Category 7 - Outdoor comfort								
I22	Air quality	1	3	1		✓	✓	✓
I23	Outdoor Thermal Comfort	1	1	1	1	✓		
I24	Acoustic Pollution	1	1	2		✓	✓	
I25	Light Pollution	1		1	1	✓		
Category 8 - Security								
I26	Street Safety	1		1				✓
I27	Natural and technological risks	1	3	2	1	✓	✓	✓
New	Adapting to climate change		1	1		✓		✓
Category 9 - Amenities								
I28	Proximity to services	1	3	1	2		✓	✓
I29	Recreational facilities	1			1		✓	✓
I30	Local food production	1			1		✓	✓
Category 10 - Mobility								
I31	Public Transport	1	4	1	3		✓	✓
I32	Pedestrian Path Accessibility	1	2	3	3		✓	✓
I33	Cycle Path Network	1	2	2	1		✓	
New	Usability of Public Transport for Physically Disabled Persons			1				
New	Car Parking Spaces		1	1	1			
Category 11 - Local and Cultural Identity								
I34	Access to Public Spaces	1		1	1		✓	✓
I35	Valuing Heritage	1		2	1		✓	✓
I36	Social inclusion and integration	1	2	5	3		✓	✓
Category 12 - Employment and economic development								
I37	Economic Viability	1			1	✓		✓
I38	Local Economy	1		1	1	✓	✓	✓
I39	Employability	1					✓	✓
C13 - Buildings								
I40	Sustainable Buildings	1		1	1	✓		✓
C14 - Environment								
I41	Environmental Management	1	1	1			✓	✓
Keys Numbers: Frequency of the use of the indicator (for one or several factors included in the indicator), ✓: aligned.								

4.3.1 Analysing the Category of Urban Form

The first category of the environmental dimension of sustainability assessment of $SBTool^{PT}$_U focuses on the analysis of the issues related to the shape of the city and urban layouts. As shown in Table 9, this category is addressed through 3 indicators, including passive solar planning, ventilation potential, and urban network. Moreover, the Frequency distribution of the categorised indicators, in $SBTool^{PT}$_Urban (2018), SNTool (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120 and SDGs, relevant to the category of urban form is a snapshot of the data, depicted in Figure 2. More information relevant to the detailed description of the indicators can be found in Table 10. The study identified that:

- **SNTool Min version** does not provide indicators with similar issues for this category,
- **BREEAM Communities** has promoted three indicators that have similar strategies to the indicators of $SBTool^{PT}$_U,
- **LEED-ND** has promoted three indicators that have similar strategies to indicators of $SBTool^{PT}$_U;
- **Levels** have promoted two indicators that are relevant to providing indoor air quality and protection of occupier health and thermal comfort, through the help of different strategies, which in this case the ventilation strategy and ability of a building (with and without building services) to maintain pre-defined thermal comfort conditions are the pertinent ones. However, this method is provided for the building scale.

Moreover, **SDGs** are aligned in-directly with the indicators of the category of urban form, through promoting the integration of climate change measures into national policies, strategies, and planning, and participating in the structure of civil society in urban planning. ISO 37120 does not support this category.

4.3.1.1 Potential New Indicators for $SBTool^{PT}$-Urban

For this category, based on the comparison of the indicators of the studied tools, the study did not find any potential new indicator to be added to $SBTool^{PT}$_Urban.

Table 9. The existing indicators of the category of Urban Form (C1), in SBToolPT_U

Indicators of the Category of Urban Form, in $SBTool^{PT}$_U			
Tool	**Category**		**Indicators**
$SBTool^{PT}$ Urban	C1-Urban form	**1**	**Passive Solar Planning:** Promoting maximisation exposure to the sun, promoting shading in summer, and minimising it in winter.
		2	**Ventilation potential:** Promoting distribution of buildings to provide the natural interior ventilation of buildings by enhancing use of prevailing winds.
		3	**Urban Network:** Promote connectivity between roads of different hierarchies, on a more human scale, reduce distances and facilitate circulation, pedestrian and cycling daily travel times.

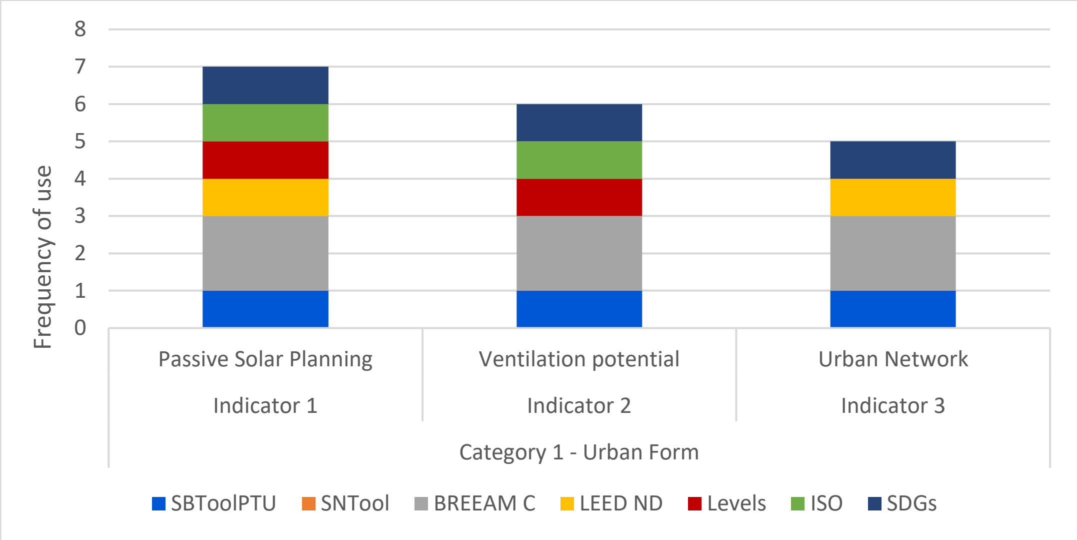


Figure 2. Frequency distribution of the indicators, relevant to the category of urban form, in SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120 and SDGs, based on SBTool[PT]_Urban (2018).

Table 10. Comparison analysis of the Category of Urban Form (C1), of SBToolPT_Urban (2018) with SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120, SDGs of Agenda 2030.

Relevant Indicators of the Category of Urban Form (C1)			**SBTool[PT]U IND**
Tools	**Categories**	**Indicators**	
SNTool Min v.	-	N/a	**-**
BREEAM Communities	Resources and energy	**RE 01 – Energy strategy:** Recommendations for reducing energy use and associated emissions by implementing energy efficient measures (e.g., site layout, topography, shading, solar orientation, use of daylighting, wind management and use of natural ventilation).	1, 2, 3
	Social and economic wellbeing	**SE 08 – Microclimate:** Recommendations for providing a comfortable outdoor environment by controlling climatic conditions on a micro scale considering the thermal comfort, solar exposure, air direction, movement and speed, dust and pollution, acoustic environment and snow buildup and ice.	1, 2
	Transport and movement	**TM 02 – Safe and appealing streets:** Recommendations for safe and secure street layouts, building orientation and buffer zones to mitigate the potential vehicle noise disturbance, potential visual and vibration disturbance from heavy vehicles to site users, and for the design of safe pedestrian and cycle routes.	3
LEED ND	Green infrastructure and buildings (GIB)	**GIB Credit – Solar orientation:** To encourage energy efficiency by creating optimum conditions for the use of passive and active solar strategies.	1
	Smart location and linkage (SLL)	**SLL Credit – Preferred locations:** Recommended for attention to location type, connectivity, and designated high-priority locations. **SLL Prerequisite – Smart location:** Recommended for development within and near existing communities and public transit infrastructure, limiting the expansion of the development footprint in the region.	3
Levels	Healthy and comfortable spaces	**4.1 Indoor air quality:** It aims to provide an approach to ensuring suitable IAQ by addressing a number of different performance aspects, namely ventilation strategy, fit-out materials, filter outdoor air, risk assessments for radon and mould, monitoring of ventilation system. Performance and pollutant levels, Occupant surveys of indoor conditions.	1
	Adaption and resilience to climate change	**5.1 Protection of occupier health and thermal comfort:** measures the proportion of the year when building occupiers are comfortable with the summer thermal conditions inside a building. It also seeks to measure the ability of a building (with and without building services) to maintain pre-defined thermal comfort conditions during the cooling season.	2

Table 10 (continued).

Relevant Indicators of the Category of Urban Form (C1)			
Tools	**Categories**	**Indicators**	**SBTool^{PT}U IND**
ISO 37120	Urban planning	21.5.2 Number of trees per 100 000 population 21.5.3 Built-up density	1,2
SDGs	Goal 11	**Make cities and human settlements inclusive, safe, resilient and sustainable.** 11.3.2 Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically.	To all
	Goal 13	**Take urgent action to combat climate change and its impacts** 13.2 Integrate climate change measures into national policies, strategies, and planning 13.2.1 Number of countries with nationally determined contributions, long-term strategies, national adaptation plans and adaptation communications, as reported to the secretariat of the United Nations Framework Convention on Climate Change.	

4.3.2 Analysing the Category of Land Use and Infrastructure

The second category of the environmental dimension of sustainability assessment of SBTool^{PT}_U focuses on the analysis of the issues related to land use and infrastructure. As shown in Table 11, this category is addressed through 5 indicators, including land natural potential, use density and flexibility, reuse of urban land, building reuse, and technical infrastructure network. Moreover, the frequency distribution of the categorised indicators, in SBTool^{PT}_Urban (2018), SNTool (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120 and SDGs, relevant to the category of land use and infrastructure is a snapshot of the data, depicted in Figure 3. More information relevant to the detailed description of the indicators can be found in Table 12. The study identified that:

- **SNTool Min version** has promoted two relevant indicators, which are contained in indicator number 5 of SBTool^{PT}_U;
- **BREEAM Communities** has promoted three relevant indicators that have similar strategies with indicators number 4, 6, and 7 of SBTool^{PT}_U;
- **LEED-ND** has promoted nine relevant indicators that have similar strategies with indicators number 4, 5, 6, and 7 of SBTool^{PT}_U;
- **Levels** has not provided indicators with similar issues in this category;

Moreover, SDGs are aligned indirectly with the indicators of the category of land use and infrastructure, from the points of different goals, especially goal 11, to make cities and human settlements inclusive, safe, resilient, and sustainable. The promoted indicator for assessing the ratio of land consumption rate to population growth rate is aligned with indicators 5, 6, and 7 of SBTool^{PT}_Urban. ISO 37120 does not support this category, except for the built-up density assessment.

4.3.2.1 Potential New Indicators for SBTool^{PT}–Urban

Relevant to the indicators of this category, SNTool (B1.8) developed an indicator for Conservation of Land, to assess the proportion of land, with ecological or agricultural value, that remained undeveloped. And, LEED-ND encouraged “Minimised site disturbance” and “Agricultural land conservation” for preserving the existing natural and agricultural resources by protecting prime and unique farmlands from development, and/or the undisturbed area for purpose of long-term conservation. However, Level(s) do not have any relevant indicator for this category, but ISO 37120 recommended to assess the "percentage of areas designated for natural protection", for promoting sustainable cities and communities. Therefore, assessing the proportion of land, with ecological or agricultural value, that remained undeveloped is an important factor, having the potential for adaptation by SBTool^{PT}-Urban.

Besides, there is a similar indicator in Category 3 of SBTool^{PT}_Urban for Ecology and Biodiversity (indicator 11: Native Vegetation) promoting the protection and increase of the ecological value characteristic of the place, through protecting or replanting of existing autochthonous plants in the existing or the new plantations, in the area. It has set calculating the percentage of native vegetation in the site, to gain a level of points. This indicator is limited to preserving or planting autochthonous plants, valued equal points for the planted and/or existing native plants in the green spaces of the site. But the indicator B1.8- Conservation of Land of SNTool, which promoted to prevent development in the site portions with ecological or agricultural values has the potential to be added to the tool.

4.3.2.2 Identifying the EU Directives related to the New Potential Indicator

Conservation of lands is an important indicator for sustainable development of urban lands and infrastructure. The relevant EU Directives are described as follows:

- The first Directive is the EU's **biodiversity** strategy based on the conservation of natural habitats and of wild fauna and flora towards the targets set for 2030, in which habitats and species should show no deterioration in conservation trends and status (EC, 2020a) (i.e., 79/409/EEC on the conservation of wild birds ('Birds Directive') and 92/43/EEC on the conservation of natural habitats and wild fauna and flora ('Habitats Directive')). Therefore, based on Target 3, clear conservation objectives and measures, and a monitoring scheme should be defined.
- The second one is **Roadmap to a Resource Efficient Europe** (EC, 2011a), with a milestone to achieve no net land take by 2050. It obligated the Member States to better integrate direct and indirect land use and its environmental impacts in their decision-making and limit land take and soil sealing to the extent possible.
- The third one is **European Green Deal** (EC, 2021c), in which the Commission presents a new Soil strategy to have all European soils restored, resilient and adequately protected by 2050. The Strategy calls for ensuring the same level of protection to soil that exists for water, the marine environment and air in the EU. This will be done through a proposal by 2023 for a new Soil Health Law, following an impact assessment and broad consultation of stakeholders and the Member States.

Table 11. The existing indicators of the category of land use and infrastructure (C2), in SBToolPT_U (2018)

Indicators of the Category of Land Use and Infrastructure, in SBTool^{PT}_U			
Tools	**Categories**	**No.**	**Indicators**
SBTool^{PT} Urban	C2 - Land Use and infrastructure	**4**	**Use the natural potential of land:** Recommendations for appropriate use of the land according to its natural potential.
		5	**Uses Density and Flexibility:** Recommendations for land-use efficiency, diversity of uses, and increase density through the building height.
		6	**Reuse of Urban Land:** Percentage of contaminated lands of the site. Promote the containment of urban expansion through the reuse of previously built land areas, as well as enhance the rehabilitation of contaminated lands. (Land recycling)
		7	**Building Reuse:** Percentage of existing buildings that have been or will be reused and rehabilitated on the site.
		8	**Technical Infrastructure Network:** Percentage of optimization of technical infrastructures

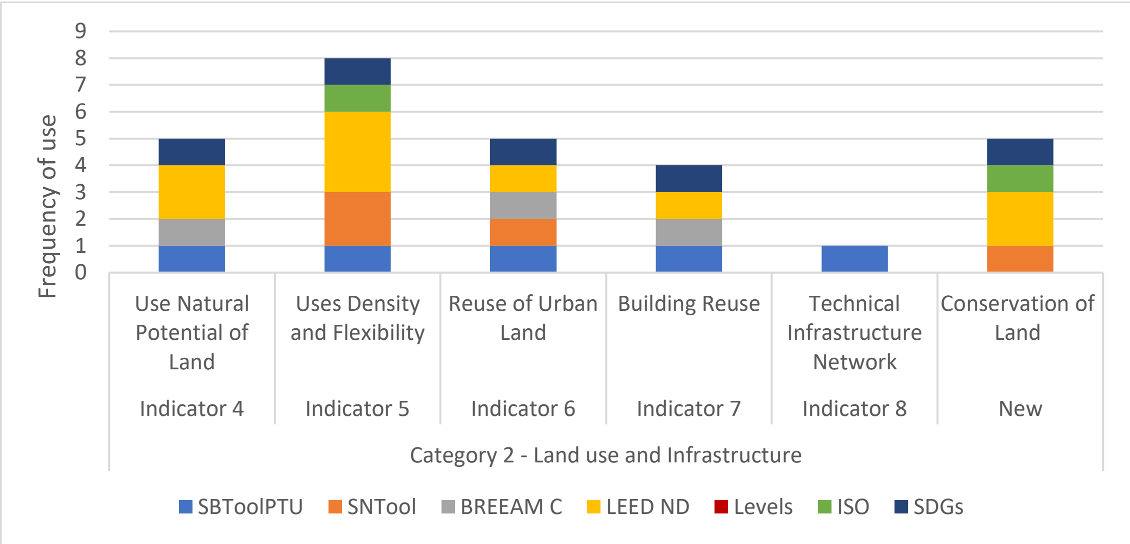


Figure 3. Frequency distribution of the indicators, relevant to the category of land use and infrastructure, in SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120 and SDGs, based on SBTool^{PT}_Urban (2018).

Table 12. Comparison analysis of the Category of land use and infrastructure (C2), of SBToolPT_Urban (2018) with SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120, SDGs of Agenda 2030.

Relevant Indicators of the Category of Land Use and Infrastructure (C2)			**SBTool^{PT}U IND**
Tools	**Categories**	**Indicators**	
SNTool Min V.	Urban Structure and Form	**B1.4 Residential density:** To determine the diversity of occupancy types in the neighborhood.	5
		B1.7 Urban diversity: To assess the density of buildings in the local area.	5
		B1.8 Conservation of Land: To determine the proportion of land, considered to be of value for ecological or agricultural purposes, that remains undeveloped.	(1)
BREEAM Communities	Land use and ecology	**LE 02 – Land use:** To encourage the use of previously developed or contaminated land and avoid land which has not been previously disturbed.	6
		LE 05 – Landscape: Recommendations to respect the character of the landscape and, where possible, enhanced.	4
	Resources and energy	**RE 02 – Existing buildings and infrastructure:** To take account of the embodied carbon in existing buildings and infrastructure and to promote their re-use where possible.	7
LEED ND	Smart location and linkage (SLL)	**SLL Credit – Brownfield remediation:** Recommendations for the cleanup of contaminated lands and developing sites that have been identified as contaminated.	6
		SLL Credit – Steep slope protection: Recommendations for steep slope protection, in the site.	4
		SLL Credit – Preferred locations: Recommendations for development within existing cities, suburbs, and towns to reduce the sprawl, and conserve natural and financial resources.	5
		SLL Prerequisite/Credit – Wetland and water body conservation: Recommendations to preserve water quality, natural hydrology, habitat, and biodiversity through conservation of wetlands and water bodies.	4
		SLL Prerequisite – Agricultural land conservation: Recommendations for preserving irreplaceable agricultural resources by protecting prime and unique farmland from development.	(1)
	Green infrastructure and	**GIB Credit – Building reuse:** Recommendations to extend the life cycle of buildings and conserve resources, reduce waste, and reduce environmental harm from materials manufacturing and transport for new buildings.	7

Table 12 (continued).

Relevant Indicators of the Category of Land Use and Infrastructure (C2)			SBToolPTU IND
Tools	**Categories**	**Indicators**	
LEED ND	buildings (GIB)	**GIB Credit – Minimized site disturbance:** Recommendations for preserving existing noninvasive trees, native plants, and pervious surfaces.	(1)
	Neighborhood pattern and design (NPD)	**NPD Credit – Mixed-use neighborhoods:** Recommendations for mixed-use developments.	5
		NPD Prerequisite/ LT Credit – Compact development and Reduced parking footprint: Recommendations for compact development, and reduced parking footprint, on the site.	5
Levels	-	N/a	-
ISO 37120	Urban planning	21.5.3 Built-up density	5
	Environment and climate change	8.4 Percentage of areas designated for natural protection	(1)
SDGs	**Goal 11**	**Make cities and human settlements inclusive, safe, resilient and sustainable** 11.3.1 Ratio of land consumption rate to the population growth rate.	5,6,7
	Goal 15	**Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.** 15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type. 15.9.1 Progress towards national targets established in accordance with Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011–2020.	4, (1)

4.3.3 Analysing the Category of Ecology and Biodiversity

The third category of the environmental dimension of sustainability assessment of SBTool^{PT}_U focuses on the analysis of the issues related to ecology and biodiversity. The intersection of biodiversity, urban environments, and people is a promising area for urban policies, aiming at reconciling urbanisation processes with biodiversity in urban regions, for the sake of both urban residents and urban nature (Kowarik et al., 2020). As shown in Table 13, this category is addressed through 4 indicators including distribution of green spaces (I9), connectivity of green spaces (I10), native vegetation (I11), and environmental monitoring (I12). A snapshot of the data regarding the frequency distribution of the categorised indicators, in SBTool^{PT}_Urban (2018), SNTool (2020), BREEAM Communities (2012), LEED-ND (2018), ISO 37120 and SDGs is depicted in Figure 4. More information relevant to the detailed description of the indicators can be found in Table 14. The study identified that:

- **SNTool Min version** has not provided indicators with similar issues for this category**;**
- **BREEAM-C** has promoted three indicators which have similar strategies with indicators number 9 and 11 of SBTool^{PT}_U;
- **LEED-ND** has promoted three indicators which have similar strategies with the indicators' number 11, and 12 of SBTool^{PT}_U, and it has a new indicator which will be analysed further;
- **Level(s)** has not provided indicators with similar issues for this category;

Moreover, SDGs are aligned with the indicators of the category of ecology and biodiversity, through SDG 11 and SDG 15. SDG 11 seeks 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. This reveals that the urban conservation strategies are integrated into the global urban Agenda. However, ISO 37120 supported this category for environmental monitoring and the distribution of green spaces, and autochthonous plant developments.

4.3.3.1 The Aligned Indicators with Different Approaches

The indicator of Environmental monitoring (I12) promotes the monitoring of the environmental aspects relevant to the site during the use phase, through the Strategic Environmental Assessment (SEA). SEA is an instrument to support decision making that aims to promote Sustainable Development. In Urban Planning, the concept of environmental monitoring appears in the initial phase, and any positive and negative impacts associated with the site are identified, described, and evaluated. Based on the verification checklist of indicator 12, the areas covered by the Environmental Monitoring Plan are water resources, fauna, flora, noise, and outdoor air quality.

BREEAM-C has an indicator for water pollution (LE 03), which has promoted putting the measures in the place to protect the local watercourse from pollution and other environmental damage, maintaining the drainage infrastructure, and measures avoid any potential water pollution during construction. This indicator is already within the scopes of Strategic Environmental Assessment (SEA) which is encouraged by indicator 12 of SBTool^{PT}_Urban.

Other indicators of the studied tools have very similar aspects and strategies to the developed indicators of SBTool^{PT}_Urban for category 2. More information relevant to the detailed description of the indicators can be found in Table 14.

4.3.3.2 A Potential New Factor for an Indicator of SBTool^{PT}–Urban

Relevant to indicator 12 for Environmental monitoring, LEED-ND developed an indicator about construction pollution prevention. This indicator recommends measures to reduce pollution from construction activities by controlling soil erosion, water pollution, and airborne dust. This indicator is already within the scope of Strategic Environmental Assessment (SEA) which is encouraged by indicator 12 of SBTool^{PT}_Urban. But, the checklist of the indicator reveals that environmental monitoring is encouraged for the occupational phase only. The environmental monitoring of the site, within the scopes of indicator 12, has the potential to be measured and monitored in the construction phase, as well. This is aligned with multiple EU directives as described in the next section.

Construction sites are often in the close proximity of homes. Due to their proximity to homes and the materials used, construction sites may generate home pollution. This involves air, water, soil, and/or noise pollution. Additionally, construction work may reveal existing subsurface pollution. In such situation, construction work is stopped, and costly remediation is needed. Thus, construction work may generate construction pollution problems affecting both homeowners and construction site owners. Moreover, construction workers may be exposed to pollution. These aspects need measures to prevent and facing the pollution, as well as to prevent the future costs for restoration.

4.3.3.3 Identifying the EU Directives related to the New Potential Indicator

The relevant EU Directives, which determine the importance of the potential new factor are described as follows:

The Council of the European Union and the European Parliament, through Directive 2008/1/EC, concerning Integrated Pollution Prevention and Control (IPPC) required a range of management actions (and other mitigation measures) to be implemented to prevent emissions into the air, water, or soil. This is also aligned with other EU Directives such as Towards Zero Pollution for Air, Water and Soil (SWD (2021) 140 final), and the proposed Horizon Europe Cities Mission, which is aligned with the zero-pollution ambition (EC, 2021a). These strategies reveal the importance of the indicator for assessing the construction pollution in the project site.

Table 13. The existing indicators of the category of ecosystems and landscapes (C3), SBTool^{PT}_Urban (2018)

Indicators of the Category of Ecology and biodiversity, in SBTool^{PT}_U			
Tools		**No.**	**Indicators**
SBTool^{PT} Urban	C3 - Ecology and biodiversity	**9**	**Distribution of Green Spaces:** Percentage of green space in the site.
		10	**Connectivity of Green Spaces:** Percentage of connected green spaces in the site.
		11	**Native Vegetation:** Percentage of native vegetation in the site.
		12	**Environmental Monitoring:** Recommendations for monitoring of the environmental quality of the site during the use phase.

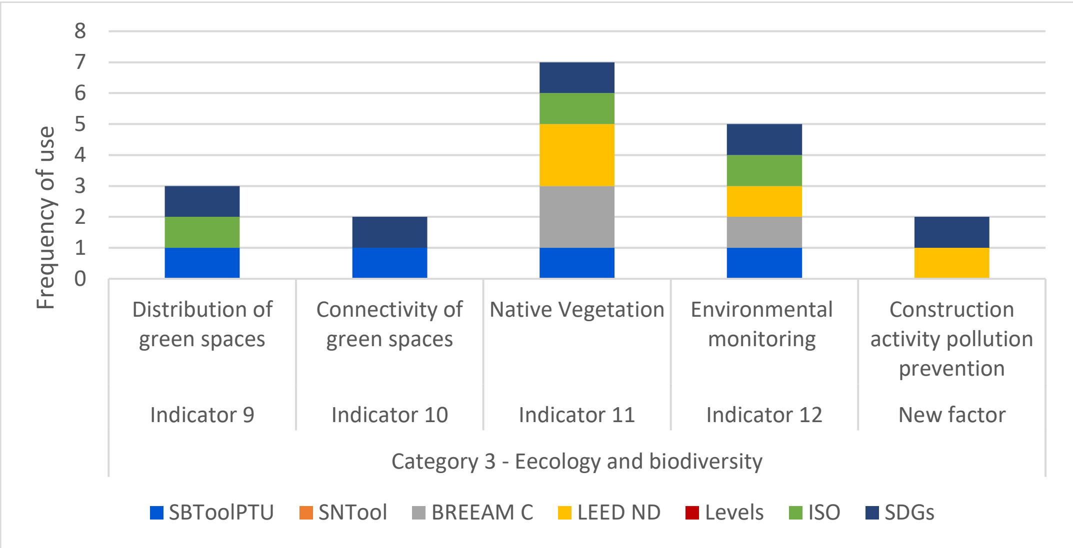


Figure 4. Frequency distribution of the indicators, relevant to the category of ecosystems and landscapes, in SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120 and SDGs, based on SBTool^{PT}_Urban (2018).

Table 14. Comparison analysis of the Category of Ecology and Biodiversity (C3), of SBTool^{PT}_Urban (2018) with SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120, SDGs of Agenda 2030.

Relevant Indicators of The Category of Ecology and Biodiversity (C3)			SBTool^{PT}U IND
Tools	**Categories**	**Indicators**	
SNTool Min V.	-	N/a	-
BREEAM Community	Land use and ecology	**LE 01 – Ecology strategy:** Recommendations to protect existing natural habitats in the site, wherever possible, and where not, minimises and mitigates its impact on existing habitats and promotes measures to enhance biodiversity on site and in the locality.	11
		LE 03 – Water pollution: Recommendations for putting the measures in the place to protect the local watercourse from pollution and other environmental damage, maintaining the drainage infrastructure, and measures to avoid any potential water pollution during construction according to best-practice guidance for pollution prevention.	12
		LE 04 – Enhancement of ecological value: Recommendations to maximise the ecological value of the site.	11
LEED ND	Smart location and linkage (SLL)	**SLL Prerequisite – Imperiled species and ecological communities' conservation:** Recommendations for conserving imperiled species and ecological communities.	11
		SLL Credit – Restoration of habitat or wetlands and water bodies: Recommendations to restore native plants, wildlife habitat, wetlands, and water bodies damaged by previous human activities.	11
		SLL Credit – Long-term conservation management of habitat or wetlands and water bodies: Recommendations to conserve native plants, wildlife habitat, wetlands, and water bodies.	12
	Green infrastructure and buildings (GIB)	**SS/GIB Prerequisite – Construction activity pollution prevention:** Recommendations to reduce pollution from construction activities by controlling soil erosion, waterway sedimentation, and airborne dust.	(2)
Levels	-	N/a	-
ISO 37120	Environment and climate change	8.9 Percentage change in number of native species	11
	Urban planning	21.1 Green area (hectares) per 100 000 population	9, 11
SDGs	Goal 15	**Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.** 5.1.1 Forest area as a proportion of total land area 15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type. 15.2.1 Progress towards sustainable forest management. 15.9.1 Progress towards national targets established in accordance with Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011–2020. 15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world. 15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species	To all
	Goal 11	**Make cities and human settlements inclusive, safe, resilient and sustainable** 11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities.	

4.3.4 Analysing the Category of Energy

The fourth category of the environmental dimension of sustainability assessment of SBTool^{PT}_U focuses on the analysis of the issues related to energy. As shown in Table 15, this category is addressed through 4 indicators including energy efficiency, renewable energies, centralised energy management. Moreover, the frequency distribution of the categorised indicators, in SBTool^{PT}_Urban (2018), SNTool (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120 and SDGs, relevant to the category of energy is a snapshot of the data, depicted in Figure 4. More information relevant to the detailed description of the indicators can be found in Table 16. The study identified that:

- **SNTool Min version** has promoted eight indicators relevant to this category, which are aligned with goals of the indicators of SBTool^{PT}_U,
  - **BREEAM Communities** has promoted one indicator (RE 01 – Energy strategy), which supports all the three indicators of SBTool^{PT}_U within,
  - **LEED-ND** has promoted three indicators, which have similar strategies with indicators of SBTool^{PT}_U,
  - **Levels** have promoted one indicator (1.1 Use stage energy performance), which is aligned with indicator 14 of SBTool^{PT}_U, and seven indicators of SNTool.

Moreover, the relevant strategies of ISO 37120 and SDG 7 are aligned with the indicators of the category of energy.

4.3.4.1 The Aligned Indicators with Different Approaches

The indicator of **Energy Efficiency** promotes a reduction in energy consumption through energy-efficient public lighting and public facilities, in order to substitute conventional street lighting with more efficient technologies in cities and urban areas. The effort cleverly combines cutting emissions and increasing energy supply while also providing towns with financial. **SNTool Min version** has an indicator for assessing the energy cost of public buildings, which in-directly is connected with this indicator.

Moreover, the indicator of **Renewable Energy** addresses the energy produced locally from renewable sources. It is covered by SNTool, through seven indicators, which assess the share of renewable energy produced locally in total: primary energy consumption, final electric energy consumption, and final electric energy consumption in a quantitative approach, and also, primary energy demand for heating, for cooling and for DHW. Moreover, Availability and access to renewable energy infrastructure is another indicator of SNTool which is aligned with this indicator. Besides, this indicator is addressed by Level(s) through measurement of the ´use stage energy performance` on the basis of the actual energy that is consumed, while if the energy is exported from the building, this should also be considered**.** This indicator is shown to be the most supported in this category, by the studied tools. Also, this indicator is recommended by a vast number of EU Directives (EC (2021b), (2020a), (2018a), (2018b), (2010a)).

4.3.4.2 A Potential New Factor for an Indicator of SBTool^{PT}_Urban

The indicator of Centralised Energy Management (SBTool^{PT}_U) focuses on controlling the use of energy for timely identification of the problems, in the network and in the systems, and increasing the potential of flexible loads in demand response. Besides, District heating and cooling (DHC) systems distribute thermal energy to multiple buildings through a network of underground pipes, and the use of thermal energy storage (TES) can offer significant economic, energy, and environmental advantages (Guillén-Lambea et al., 2021). LEED-ND has promoted an indicator for using ´district heating and cooling` strategies. This factor has the potential to be added to the checklist points of the indicator 15 of category 5 for energy in SBTool^{PT}_Urban.

4.3.4.3 Identifying the EU Directives related to the New Potential Indicator

The relevant EU Directives, regarding the developing the district heating and cooling in the neighbourhoods**,** based on the implementation of Directive 2010/31/EU on the energy performance of buildings (recast) (EC., 2010a), the Member States should enable and encourage architects and planners to properly consider the optimal combination of improvements in energy efficiency, use of energy from renewable sources and use of district heating and cooling when planning, designing, building, and renovating industrial or residential areas. The study proposed to incorporate the factor relevant with assessment of "District Heating and Cooling Systems" to indicator 15, which is relevant with the assessment of Centralised Energy Management. The initiative is also encouraged by the United Nations Environment Programme (UNEP, 2021), and is one of six accelerators of the Sustainable Energy for All (SEforAll) in Energy Efficiency Accelerator Platform. The Initiative is supporting market transformation efforts to shift the heating and cooling sector to energy efficient and renewable energy solutions. These strategies reveal the importance of the indicator District heating and cooling systems to be added to the tool.

Table 15. The existing indicators of the category of energy (C4), SBTool^{PT}_Urban (2018)

Indicators of the Category of Energy, in SBTool^{PT}_U			
Tools	**Categories**		**Indicators**
SBTool^{PT} Urban	Energy	**13**	**Energy Efficiency:** Promoting energy efficiency in public spaces, by reducing energy consumption and energy-consuming systems by public lighting and dynamic control systems.
		14	**Renewable Energies:** promoting local renewable energy production, or the availability of renewable energy sources in the region, by calculating the percentage of renewable energy produced locally (per) in relation to the estimated energy consumption for the project.
		15	**Centralised Energy Management:** Promoting energy management systems in the systems that use energy in public spaces.

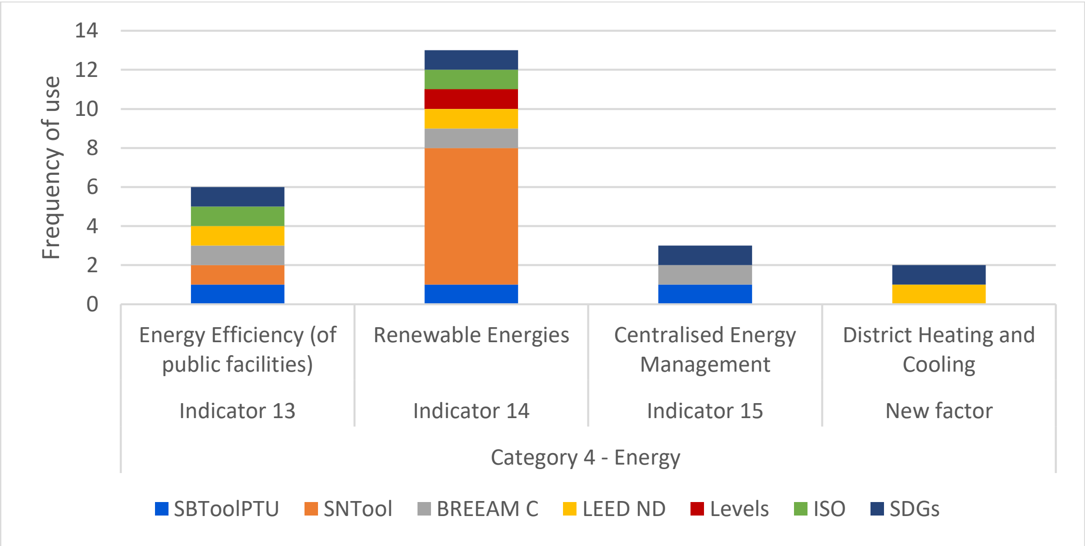


Figure 5. Frequency distribution of the indicators, relevant to the category of energy, in SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120 and SDGs, based on SBTool^{PT}_Urban (2018).

Table 16. Comparison analysis of the Category of Energy (C4), of SBToolPT_Urban (2018) with SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120, SDGs of Agenda 2030.

Relevant Indicators of the Category of Energy (C4)			
Tools	**Categories**	**Indicators**	**SBTool PT U IND**
SNTool Min V.	Renewable and Decarbonized energy	**D2.1 Share of renewable energy generated on-site, relative to total final energy consumption for the operation of all buildings**: To incentivize the consumption and production of renewable energy.	14
		D2.4 Share of renewable energy generated on-site, relative to total primary energy consumption for the operation of all buildings: To incentivize the consumption and production of renewable energy.	14
		D2.7 Share of renewable energy generated in the local area, relative to the total final electric energy consumption: To incentive the consumption and production of renewable energy.	14
	Other local infrastructure	**B3.5 Availability and access to renewable energy infrastructure:** Availability and access to public or private renewable energy supplies for all permanent buildings in the area.	14
	Cost and Investment	**C3.3 Operating energy costs for public buildings:** To assess the cost of energy services for public buildings.	13
	Non-renewable energy, aggregated	**D1.7 Primary energy demand for heating of residential buildings:** To reduce the need for energy for heating residential buildings.	14
		D1.10 Primary energy demand for cooling of non-residential buildings: To reduce the need for energy for cooling non-residential buildings.	14
		D1.11 Primary energy demand for DHW in residential buildings	14
BREEAM Communities	Resources and energy	**RE 01 – Energy strategy:** prediction of energy demand (heating, cooling and electricity demand) and associated emissions, including the site heating, cooling and electricity demand, emissions for regulated and unregulated energy use, and street lighting and other street infrastructures. Moreover, opportunities to reduce emissions by using centralized energy systems.	13, 14, 15
LEED ND	Green infrastructure and buildings (GIB)	**GIB Credit – Infrastructure energy efficiency:** To reduce the environmental harms from energy used for operating public infrastructure (e.g., traffic lights, streetlights, water, and wastewater pumps).	13
		GIB Credit – District heating and cooling: Recommendation for using district heating and cooling strategies that reduce energy use and energy-related environmental harms.	(3)-15
		GIB Credit – Renewable energy production: To reduce the environmental and economic harms associated with fossil fuel energy by increasing the self-supply of renewable energy.	14
Levels	Greenhouse gas emissions along a building's life cycle	**1.1 Use stage energy performance (kWh/m2/yr):** the energy needs associated with the type of building they are working on and know where they can focus attention to reduce the total primary energy use associated with the building's delivered energy needs during the use stage. It measures the energy performance of a building, based on the calculated or actual energy that is consumed, in order to meet the different energy needs associated with its typical use. This requires energy carriers, such as electricity, natural gas and biomass, which are directly used in the building to provide power, heat and hot water. If energy is exported from the building, this should also be considered.	14
ISO 37120	Energy	**7.1 Total end-use energy consumption per capita** **7.5 Final energy consumption of public buildings per year** **7.6 Electricity consumption of public street lighting per kilometre of lighted street**	13
		7.2 Percentage of total end-use energy derived from renewable sources	14
SDGs	Goal 7	**Ensure access to affordable, reliable, sustainable, and modern energy for all** 7.2.1 Renewable energy share in the total final energy consumption. 7.3.1 Energy intensity measured in terms of primary energy and GDP.	To all

Table 16 (continued).

Relevant Indicators of the Category of Energy (C4)			$SBTool^{PT}U$ IND
Tools	**Categories**	**Indicators**	
SDGs	Goal 7	7.b.1 Investments in energy efficiency as a percentage of GDP and the amount of foreign direct investment in financial transfer for infrastructure and technology to sustainable development services.	
	Goal 9	**Build resilient infrastructure, promote sustainable industrialization and foster innovation** 9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all. 9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	(3)
	Goal 11	**Make cities inclusive, safe, resilient and sustainable** 11.B By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels	(3)

4.3.5 Analysing the Category of Water

The fifth category of the environmental dimension of sustainability assessment of $SBTool^{PT}$_U focuses on the analysis of the issues related to water. As shown in table 17, this category is addressed through 3 indicators, including efficient drinking water consumption, effluent management, and centralised water management. Moreover, a snapshot of the data relevant with the frequency distribution of the categorised indicators to the category of water, in $SBTool^{PT}$_Urban (2018), SNTool (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120 and SDGs, depicted in Figure 6. More information relevant to the detailed description of the indicators can be found in Table 18. Accordingly, the study identified that:

- **SNTool Min version** has promoted two indicators relevant to this category, which are aligned with the goals of the indicators of $SBTool^{PT}$_U. Although, the indicator of SNTool has a quantitative approach, and is developed for households, whereas $SBTool^{PT}$_U used a qualitative approach, and assessing the public spaces;
- **BREEAM Communities** has promoted three indicators that have similar strategies to the indicators of $SBTool^{PT}$_U;
- **LEED-ND** has promoted three indicators that have similar strategies to indicators of $SBTool^{PT}$_U;
- **Levels** have promoted two indicators for calculating use stage water consumption and promoting solutions in the design stage to embrace sustainable drainage, in a quantitative approach.

Efficient water consumption is targeted by SDG 12 for sustainable consumption and production. Furthermore, effluent management is targeted by SDG 6, which emphasises sustainable management of water and sanitation. Also, ISO 37120 supported all three indicators of $SBTool^{PT}$_U.

4.3.5.1 The Aligned Indicators with Different Approaches

Indicator 16 of category 5, Efficient Drinking Water Consumption, promotes efficient solutions for reducing water consumption in public spaces, and improvement of water conservation practices in green spaces (e.g., water efficiency is considered in the selection of tree, shrub, and herbaceous planting specifications and any associated irrigation systems). It is promoted by SNTool, through a quantitative approach indicator, which assesses the consumption of potable water in residential households. This indicator is also promoted by Level(s) in the quantitative approach by the indicator ´Use stage water consumption`. The measurement of water consumption in the cities can enable an improvement in the performance of water distribution systems (Cutore et al., 2008). But, efficient water consumption in cities as well, leads to the enhancement of investing in sustainable urban water infrastructures, which is targeted by SDG 12 for sustainable consumption and production. Therefore, indicator 16 of SBTool^{PT}Urban already covered this issue.

Moreover, indicator 17, Effluent Management, promotes the recharge of underground water reserves, which are under decontamination condition, reduce the risk of flooding, and reduce the load on public drainage and effluent treatment systems. This indicator promotes the use of domestic wastewater treatment systems in response to the increased needs of the site. This indicator is promoted by SNTool through assessment of the `availability and access to a public sewage disposal and treatment system´ in the local area. Level(s) also, established the indicator of `Sustainable drainage´ to encourage the use of sustainable drainage options to reduce the chances of pluvial flood events in the local area and fluvial flood events downstream from occurring in the first place. Therefore, indicator 17 of SBTool^{PT}Urban already covered these areas as well.

Table 17. The existing indicators of the category of water (C5), SBTool^{PT}_Urban (2018)

Indicators of the Category of Land Use and Infrastructure, in SBTool^{PT}_U			
Tools	**Categories**	**No.**	**Indicators**
SBTool^{PT} Urban	C5 - Land Use and infrastructure	**16**	**Efficient Drinking Water Consumption:** Recommendations for water conservation practices and reduce water consumption in public spaces, by simultaneously reducing the production of effluents and pressure in the drainage systems.
		17	**Effluent Management:** Recommendations to recharge of underground reserves, reducing the risk of flooding and the load on public drainage and effluent treatment systems, and to promote the adequate dimensioning of domestic wastewater treatment systems, responding to the needs increased by the project.
		18	**Centralised Water Management:** Recommendations for controlling water consumption centralised water systems.

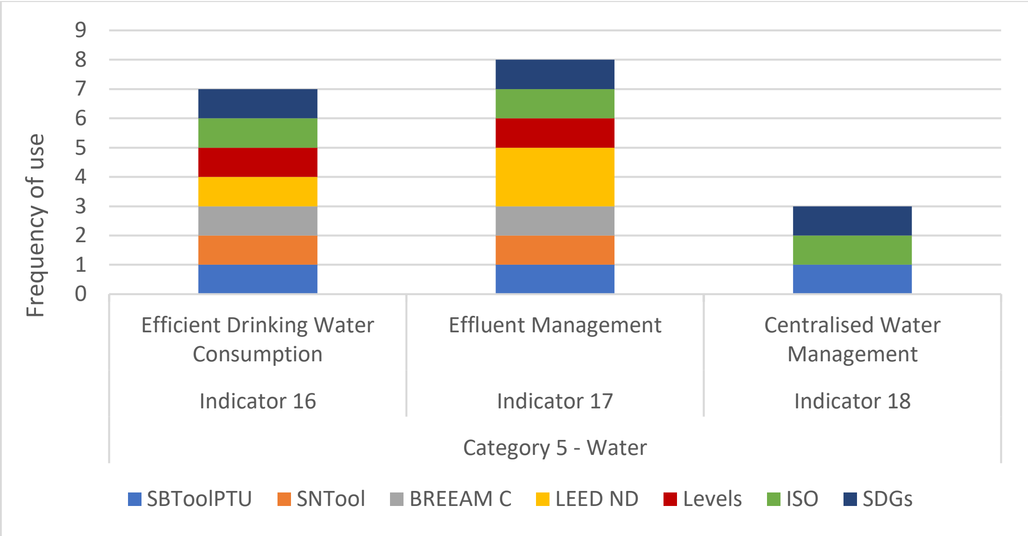


Figure 6. Frequency distribution of the indicators, relevant to the category of water, in SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120 and SDGs, based on SBTool^{PT}_Urban (2018).

Table 18. Comparison analysis of the Category of water (C5), of SBTool^{PT}_Urban (2018) with SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120, SDGs of Agenda 2030.

Indicators of the Category of Water (C5)			SBTool^{PT}U IND
Tools	**Categories**	**Indicators**	
SNTool Min V.	Potable water,stormwater and greywater	**E1.5 consumption of potable water by residential households:** To reduce the consumption of potable water.	16
	Other local infrastructure	**B3.2 Availability and access to a public sewage disposal and treatment system:** To assess the percent of permanent buildings with access to public sewage disposal and treatment system.	17
Levels	Efficient use of water resources	**3.1 Use stage water consumption (m3/occupant/yr):** The total consumption of water is measured for an average building occupant, with the option to split this value into potable and non-potable water.	16
	Adaption and resilience to climate change	**5.3 Sustainable drainage:** Set out the steps to take during the conceptual design stage in order to embrace sustainable drainage options to reduce the chances of pluvial flood events in the local area and fluvial flood events downstream from occurring in the first place.	17
BREEAM Communities	Resources and energy	**RE 03 – Water strategy (Resources and energy):** Recommendations to develop overall water consumption targets, and to manage water demand on the development site to meet the consumption targets.	16
	Land use and ecology	**LE 06 – Rainwater harvesting:** To ensure that surface water run-off space is used effectively to minimize water demand.	17
LEED ND	Smart location and linkage (SLL)	**WE Credit – Outdoor/ Indoor water use reduction –** To reduce outdoor water consumption through non-vegetated surfaces.	16
	Green infrastructure and buildings (GIB)	**SS Credit – Rainwater management:** To reduce runoff volume and improve water quality by replicating the natural hydrology and water balance of the site, based on historical conditions and undeveloped ecosystems in the region.	27, 17
		GIB Credit – Wastewater management: To reduce pollution from wastewater and encourage water reuse.	17
	Smart location and linkage (SLL)	**SLL Prerequisite – Floodplain avoidance:** To protect life and property, promote open space and habitat conservation, and enhance water quality and natural hydrologic systems.	27, 17
ISO 37120	Water	23.2 Percentage of city population with sustainable access to an improved water source. 23.3 Total domestic water consumption per capita Percentage of city 23.4 Compliance rate of drinking water quality. 23.5 Total water consumption per capita. 23.7 Percentage of water loss	16

Table 18 (continued).

Indicators of the Category of Water (C5)			SBToolPTU IND
Tools	**Categories**	**Indicators**	
ISO 37120	Wastewater	22.1 Percentage of city population served by wastewater collection 22.4 Compliance rate of wastewater treatment	17
		22.2 Percentage of city's wastewater receiving centralized treatment 22.3 Percentage of population with access to improved sanitation	18
SDGs	Goal 6	**Ensure availability and sustainable management of water and sanitation for all** 6.1.1 Proportion of population using safely managed drinking water services. 6.3.1 Proportion of wastewater safely treated. 6.6.1 Change in the extent of water-related ecosystems over time. 6.a.1 Amount of water and sanitation-related official development assistance that is part of a government-coordinated spending plan. 6.b.1 Proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management.	To all

4.3.6 Analysing the Category of Materials and Wastes

The sixth category of the environmental dimension of sustainability assessment of SBTool^{PT}_U focuses on the analysis of the issues related to the materials and wastes. As shown in Table 19, this category is addressed through 3 indicators, including: low impact materials, construction and demolition waste, and urban solid waste management. Moreover, the frequency distribution of the categorised indicators, in SBTool^{PT}_Urban (2018), SNTool (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120 and SDGs, relevant to the category of materials and wastes is depicted in Figure 7 as a snapshot of the data. More information relevant to the detailed description of the indicators can be found in Table 20. The study identified that:

- **SNTool Min version** has promoted two indicators relevant to this category, which are aligned with the goals of the indicators of SBTool^{PT}_U, and it has a new indicator which will be analysed further;
- **BREEAM Communities** has promoted three indicators, which are similar with the indicators number 19, and 20 of SBTool^{PT}_U;
- **LEED ND** has promoted two indicators, which have similar strategies with the indicators' number 20, and 21 of SBTool^{PT}_U;
- **Levels** has promoted four indicators, which are aligned with the indicators of the tool.

The construction sector uses a lot of heavy non-renewable resources such as cement, concrete, and steel that leave a high carbon footprint. Therefore, the construction industry is known to have a huge potential for improving sustainability through adopting measures for using renewable materials, reuse of recycled materials, and using low-impact materials. This issue is emphasised 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 to protect public health and the environment. ISO 37120 also, has promoted the assessing the issue of the city's solid waste that is disposed of in a sanitary landfill and recycled.

4.3.6.1 The Aligned Indicators with Different Approaches

Indicator 19 for **Low Impact Materials** promotes recommendations for the application of sustainable materials in public spaces, to reduce the environmental impacts associated with the extraction, production, transportation, and use of construction materials. The main factors that are considered in this category to be assessed are including the percentage use of certified wood, fast renewable materials, recycled and reused materials, and local or locally produced materials. This indicator is within the scope of the Roadmap to a Resource Efficient Europe (EC, 2011a), which addresses measures to increase resource efficiency and decouple economic growth from resource consumption and its environmental impact, By 2050. Also, this indicator is supported by Level(s) through the indicator of ´Design for deconstruction, reuse and recycling`. Level(s) provides a semi-quantitative assessment of the extent to which the design of a building could facilitate the future recovery of materials for reuse of recycling, measures the ease of disassembly for a minimum scope of building parts, followed by the ease of reuse and recycling for these parts and their associated sub-assemblies and materials. Therefore, the indicator of the Level(s) relevant to resource efficiency is already included in the factors which are considered for assessing indicator 19 of SBTool^{PT}-Urban.

4.3.6.2 A Potential New Factor for an Indicator of SBTool^{PT}-Urban

Relevant to indicator 19 for Low Impact Materials, **SNTool** (F4.1) developed an indicator for the assessment of GHG emissions from energy embodied in construction materials used for construction, maintenance, or replacement(s). Besides, **Level(s)** have encouraged to assess the ´Bill of quantities, materials, and lifespans` to estimate and measure the mass of construction products and materials. It offers the possibility to allocate specific lifetimes to each building element and material. Life cycle assessment also is a technique to assess environmental impacts associated with all the stages of a product's life, which is from raw material extraction through materials processing, manufacture, distribution, and use (Iyyanki V. et al., 2017) Life cycle assessments in the construction industry reveal that 70–80% of all CO2 emissions occur precisely at the stage of material production (stages A1–A3 of the life cycle) (Zaborova & Musorina, 2022). Therefore, assessing the GHG emissions embodied in the used construction materials is an important factor, which is defined in these three tools.

Embodied energy (EE) and embodied carbon (EC) of building materials consists of all the energy expended and all the GHG emissions emitted in producing final building materials, from the extract of natural resources to manufacturing processes and transport, as well as the operational and end-of-life emissions associated with those materials (Chen et al., 2022). However, embodied carbon is more difficult to measure and track than operational carbon, which is relatively simple to extrapolate from occupants' energy bills. Determining the embodied carbon of any building material is impossible to ascertain from the finished product alone and requires self-assessment and process transparency on the part of the manufacturer. Two materials may look identical, cost the same amount, and perform to the same standard—but have totally different embodied carbon characteristics. For example, a 100 percent recycled-steel beam produced using renewable energy may appear identical to a virgin-steel beam produced using a coal-fired furnace—but have significantly different levels of embodied carbon. Where each steel beam came from and how far it was transported add further complexity. However, using simulation tools and integrating Embodied Carbon in Construction calculating with standard building-information modelling (BIM) tools can further extend its utility. The study identified this factor as an important factor which can be added to the indicator 19. The study proposed to incorporate the factor relevant with assessment of "GHG emissions embodied in the used construction materials" to indicator 19, which is relevant with the assessment of Low Impact Materials.

Table 19. The existing indicators of the category of materials and wastes (C6), SBTool^{PT}_Urban (2018)

Indicators of the Category of Materials and wastes, in SBTool^{PT}_U			
Tools	**Categories**	**No.**	**Indicators**
SBTool^{PT} Urban	**C6 - Materials and wastes**	19	Low Impact Materials: Recommendations for the application of sustainable materials in public spaces
		20	Construction and Demolition Waste: Recommendations for reuse of the construction and demolition waste at the site.
		21	Urban Solid Waste Management: Recommendations for the selective separation of waste and the implementation of recovery systems.

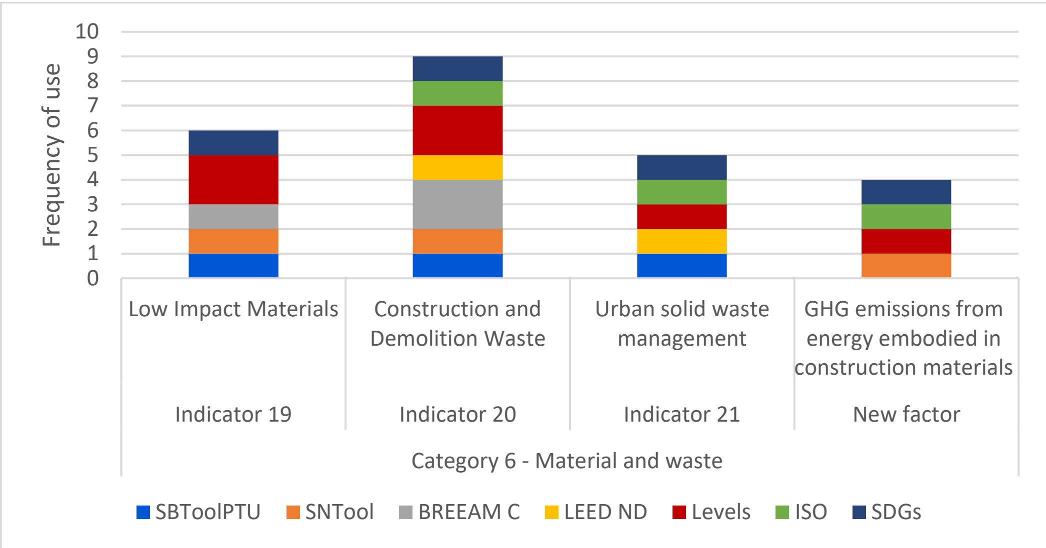


Figure 7. Frequency distribution of the indicators, relevant to the category of materials and wastes, in SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120 and SDGs, based on SBTool^{PT}_Urban (2018).

Table 20. Comparison analysis of the Category of Materials and wastes (C6), of SBTool^{PT}_Urban (2018) with SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120, SDGs of Agenda 2030.

Relevant Indicators of the Category of Materials and wastes (C6)			**SBTool^{PT}U IND**
Tools	**Categories**	Indicators	
SNTool Min V.	Resource consumption, reuse, and maintenance	**E3.1 Consumption of materials for non-renewable material resources for construction or renovation of buildings:** Total consumption of non-renewable material.	19
		E3.3 Percentage of reused or recycled materials used for construction or renovation: Quantity of reused or recycled materials used for construction or renovation in the local area, as a percent of total materials used.	20
	Atmospheric emissions	**F4.1 GHG emissions from energy embodied in construction materials used for construction, maintenance, or replacement(s).**	(4)
BREEAM Communities	Resources and energy	**RE 02 – Existing buildings and infrastructure (Resources and energy)**: Recommendations to take account of the embodied carbon in existing buildings and infrastructure and to promote their re-use where possible.	20
		RE 05 – Low impact materials: Recommendations to reduce the environmental impact of construction, using low impact materials in the public realm (e.g., Sustainable materials, Reused materials, No new materials, locally reclaimed.)	19
		RE 06 – Resource efficiency: Recommendations to promote resource efficiency by maximizing the recovery of material from demolition or refurbishment for subsequent high-grade applications.	20

Table 20 (continued).

Relevant Indicators of the Category of Materials and wastes (C6)			SBTool^{PT}U IND
Tools	**Categories**	Indicators	
LEED ND	Green infrastructure and buildings (GIB)	**GIB Credit – Recycled and reused infrastructure:** Recommendations to avoid the environmental consequences of extracting and processing virgin materials by using recycled and reclaimed materials.	20
		GIB Credit – Solid waste management: Recommendations to reduce the volume of waste deposited in landfills and promote the proper disposal of hazardous waste.	21
Levels	Greenhouse gas emissions along a building's life cycle	**1.2 Life cycle Global Warming Potential (CO2 eq./m2/yr):** It aims to quantify the Global Warming Potential (GWP) contributions of a building along its life cycle from the 'cradle' – the extraction of the raw materials that are used construction the building - through to the 'grave' – the deconstruction of the building and how to deal with its building materials (recovery, reuse, recycling and waste management).	19, 20
	Resource efficient and circular material life cycles	**2.1 Bill of quantities, materials and lifespans:** It estimate and measure the mass of construction products and materials necessary to complete defined parts of the building. It offers the possibility to allocate specific lifetimes to each building element/material.	(4)
		2.2 Construction & Demolition waste and materials: to promote and allow users to systematically plan for the reuse, recycling or recovery of elements, materials, and wastes via the segregated collection of CDW during construction, renovation, and demolition activities.	20, 21
		2.4 Design for deconstruction, reuse, and recycling: It provides a semi-quantitative assessment of the extent to which the design of a building could facilitate the future recovery of materials for reuse of recycling. It measures the ease of disassembly for a minimum scope of building parts, followed by the ease of reuse and recycling for these parts and their associated sub-assemblies and materials.	19
ISO 37120	Solid waste	16.1 Percentage of city population with regular solid waste collection. 16.4 Percentage of the city's solid waste that is disposed of in a sanitary landfill	21
		16.3 Percentage of the city's solid waste that is recycled 16.8 Percentage of the city's solid waste that is disposed of by other means	20
	Environment and climate change	8.3 Greenhouse gas emissions measured in tonnes per capita	(4)
SDGs	**Goal 8**	**Promote sustained, inclusive, and sustainable economic growth, full and productive employment and decent work for all.** 8.4.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP.	To all
	Goal 11	**Make cities and human settlements inclusive, safe, resilient, and sustainable** 11.6.1 Proportion of urban solid waste regularly collected and with adequate final discharge out of total urban solid waste generated, by cities.	
	Goal 12	**Ensure sustainable consumption and production patterns** 12.2.1 Material footprint, material footprint per capita, and material footprint per GDP. 12.2.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP. 12.4.1 Number of parties to international multilateral environmental agreements on hazardous waste, and other chemicals that meet their commitments and obligations in transmitting information as required by each relevant agreement. 12.4.2 Hazardous waste generated per capita, and proportion of hazardous waste treated, by type of treatment. 12.5.1 National recycling rate, tons of material recycled. 12.6.1 Number of companies publishing sustainability reports.	

4.3.6.3 Identifying the EU Directives related to the New Potential Indicator

The relevant EU Directives, which determine the importance of the potential new factor, which can be added to indicator 19 are described as follows:
Based on the proposal for a DIRECTIVE on the energy performance of buildings (15.12.2021 COM (2021) 802 final 2021/0426 (COD)) (EC, 2021b), on provision of new buildings, recommend that: The life-cycle Global Warming Potential (GWP) of new buildings will have to be calculated as of 2030 in accordance with the Level(s) framework, thus informing on the whole-life cycle emissions of new construction. Whole-life cycle emissions are particularly relevant for large buildings, which is why the obligation to calculate them already applies to large buildings (with a useful floor area larger than 2000 square meters) as of 2027.

4.3.7 Analysing the Category of Outdoor Comfort

The seventh category of the environmental dimension of sustainability assessment of SBTool^{PT}_U focuses on the analysis of the issues related to outdoor comfort. As shown in Table 21, this category is addressed through 4 indicators, including Air Quality (I22), Outdoor Thermal Comfort (I23), Acoustic Pollution (I24), and Light Pollution (I25). Moreover, a snapshot of the data regarding the frequency distribution of the categorised indicators, in SBTool^{PT}_Urban (2018), SNTool (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120 and SDGs is depicted in Figure 7. Accordingly, the study identified that:

- **SNTool Min version** has promoted three indicators that have similar strategies to the indicators of SBTool^{PT}_U. They have used a quantitative approach, whereas SBTool^{PT}_U used a qualitative approach. Moreover, it has two indicator (F4.2/ F4.5 Aggregate GHG Emissions from primary energy used in building operation/ private vehicles) which are not included in the tool;
- **BREEAM Communities** has promoted five indicators that have similar strategies to the indicators of SBTool^{PT}_U;
- **LEED-ND** has promoted two indicators that have similar strategies to indicators of SBTool^{PT}_U;
- **Levels** have promoted four indicators in building scale that have the same strategies that the SBTool^{PT}_U is defined and encouraged.

Moreover, SDGs 9 and 11 are aligned with indicators 22 for air quality and ISO 37120 also, has promoted seven indicators which supported this indicator and indicator 24 for noise pollution.

4.3.7.1 The Aligned Indicators with Different Approaches

The indicator of **Air Quality** assesses the outdoor air quality to promote the reduction of the pollutants in outdoor spaces. Therefore, the implementation of preventive measures and strategies to reduce the concentration of air pollutants is developed to increase air quality and improve the health and comfort of the inhabitants of urban areas. **SNTool Min version** has an indicator for assessing the Aggregate GHG Emissions from primary energy used in building operations and in private vehicles. The intention of this indicator is to reduce air pollution, which affects the environmental air quality of the neighbourhoods, which is aligned with the targets of indicator 22 of SBTool^{PT}_Urban.

In addition, **Level(s)** has promoted four indicators for assessment of Indoor air quality, Time outside of thermal comfort range, Lighting and visual comfort, and Acoustics and protection against noise. The four mentioned indicators are aligned with the indicators of SBTool^{PT}_Urban. However, the indicators of the Level(s) are promoted in a building scale but reveals that the SBTool^PT_Urban indicators are in accordance with the Level(s) framework.

Other indicators of the studied tools have very similar aspects and strategies with the developed indicators of SBTool^PT_Urban for category 7. More information relevant to the detailed description of the indicators can be found in Table 22.

Table 21. The existing indicators of the category of outdoor comfort (7), SBTool^PT_Urban (2018)

			Outdoor comfort
Tools	**Categories**	**No.**	**Indicators**
SBTool^PT Urban	C7 - Outdoor environmental quality	**22**	**Air Quality:** Recommendations for assessing the outdoor air quality to promote the reduction of pollutants in outdoor spaces.
		23	**Outdoor Thermal Comfort:** Recommendations to improve the comfort of inhabitants in outdoor spaces of the site, and for assessing the percentage of spaces that provide thermal comfort.
		24	**Acoustic Pollution:** Recommendations for reduction of outside noise in order to improve the acoustic comfort of the inhabitants of the site.
		25	**Light Pollution:** Recommendations to avoid light pollution through the efficient dimensioning of public lighting, promoting the reduction of brightness in the sky, glare and intrusive light (inside homes).

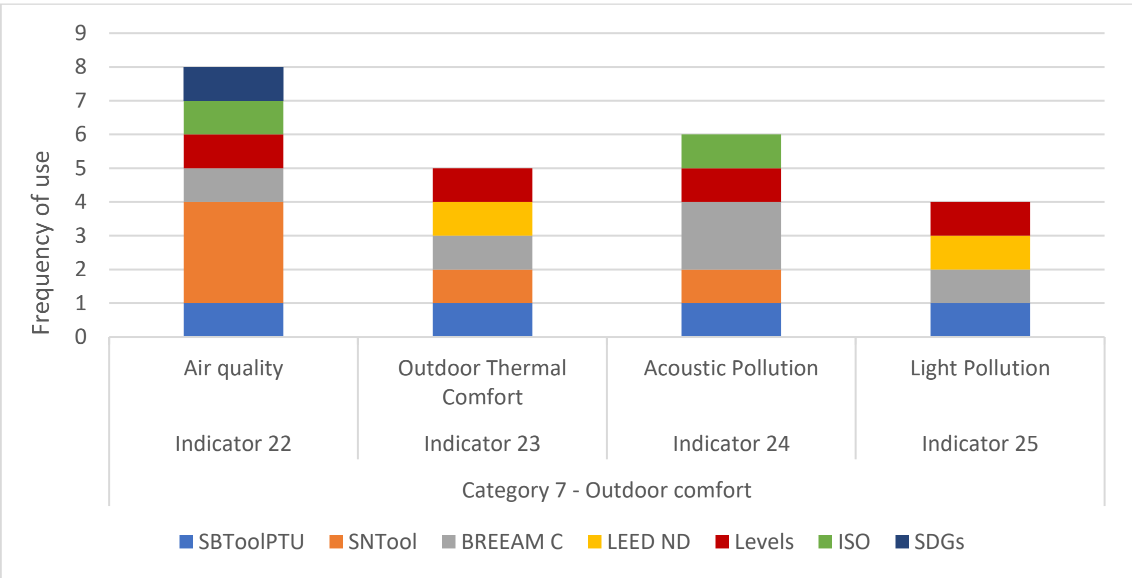


Figure 8. Frequency distribution of the indicators, relevant to the category of outdoor comfort, in SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120 and SDGs, based on SBTool^PT_Urban (2018).

Table 22. Comparison analysis of the Category of Outdoor Comfort (C7), of SBToolPT_Urban (2018) with SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120, SDGs of Agenda 2030.

Relevant Indicators of the Category of Outdoor Comfort (C7)			**SBTool^{PT}U IND**
Tools	**Categories**	**Indicators**	
SNTool Min V.	Environmental impacts	**F2.5 Heat Island Effect in the local area:** To estimate the extent of the Urban Heat Island effect in the local area.	23
	Outdoor environmental quality	**F3.1 Ambient air quality, ozone:** To assess the long-term ambient air quality with respect to PM2.5, in the local area.	22
		F3.11 Ambient night-time noise conditions: To assess acoustic comfort of the site.	24
	Atmospheric emissions	**F4.2 Aggregate GHG Emissions from primary energy used in building operation:** To estimate the emissions resulting from the operation of buildings for heating, cooling, ventilation, domestic hot water, lighting, and auxiliaries.	22
		F4.5 Aggregate annual GHG emissions from the use of private vehicles: To estimate greenhouse gas (GHG) emissions resulting from the operation of private vehicles in the local area.	22
BREEAM Communities	Social and economic wellbeing	**SE 04 – Noise pollution:** Recommendations for assessing the existing noise disturbance of the site, and if necessary, providing for attenuation of on-site noise, etc.	24
		SE 08 – Microclimate: Recommendations for takes full account of microclimatic conditions for the location and design of pedestrian and cycling routes, to considered for temperature and thermal comfort, solar exposure, air direction, movement and speed, dust and pollution, acoustic environment, and Snow buildup and ice.	23, 24
		SE 16 – Light pollution: Recommendations for minimizing light pollution.	25
	Resources and energy	**RE 01 – Energy strategy:** prediction of energy demand and associated emissions, including the site heating, cooling and electricity demand, and emissions for regulated and unregulated energy use, and street lighting and other street infrastructures. Moreover, opportunities to reduce emissions by using decentralized energy systems.	22
LEED ND	Green infrastructure and buildings (GIB)	**SS/ GIB Credit – Heat Island reduction:** Recommendations to minimize effects on microclimates and human and wildlife habitats by reducing heat islands.	23
		SS/ GIB Credit – Light pollution reduction: Recommendations to increase night sky access, improve nighttime visibility, and reduce the consequences of development for wildlife and people.	25
Levels	Healthy and comfortable spaces	**4.1 Indoor air quality**	22
		4.2 Time outside of thermal comfort range	23
		4.3 Lighting and visual comfort	24
		4.4 Acoustics and protection against noise	25
ISO 37120	Environment and climate change	8.1 Fine particulate matter (PM2.5) concentration 8.2 Particulate matter (PM10) concentration 8.5 NO2 (nitrogen dioxide) concentration 8.6 SO2 (sulfur dioxide) concentration 8.7 O3 (ozone) concentration	22
		8.8 Noise pollution	24
SDGs	Goal 11	**Make cities and human settlements inclusive, safe, resilient and sustainable** 11.6.2 Annual mean levels of fine particulate matter (e.g., PM2.5 and PM10) in cities (population weighted).	22
	Goal 9	**Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation** 9.4.1 CO2 emission per unit of value added	22

4.3.8 Analyzing the Category of Security

The eighth category, the social dimension, of sustainability assessment of SBTool^{PT}_U focuses on the analysis of the issues related to security, based on vulnerabilities of the context. As shown in Table 23, this category is addressed through 2 indicators, including Street Safety (I26), and Natural and technological risks (I27). Moreover, a snapshot of the data regarding the frequency distribution of the categorised indicators, in SBTool^{PT}_Urban (2018), SNTool (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120 and SDGs is depicted in Figure 9. More information relevant to the detailed description of the indicators can be found in Table 24. The study identified that:

- **SNTool Min version** has promoted five indicators relevant to estimating of the natural disaster risks of the buildings on the site. They have used a quantitative approach, whereas SBTool^{PT}_U used a qualitative approach. Moreover, it has two indicators (F4.2/ F4.5 Aggregate GHG Emissions from primary energy used in building operation/ private vehicles) which are not included in the tool;
- **BREEAM Communities** has promoted three indicators that are relevant to climate change issues and the vulnerability of buildings to natural risks;
- **LEED-ND** has promoted one indicator relevant to the vulnerability of buildings to natural risks;
- **Level(s)** has promoted two indicators that are relevant to climate change issues and the vulnerability of buildings to natural risks;

Climate-related disasters have increased in the previous three decades as a result of current global climate change, showing a new and alarming degree of damage and devastation (Oxfam international, 2022). These failures have led to casualties, property destruction, and vast economic loss. Many studies have acknowledged the importance of identifying the various vulnerabilities of the communities and analysing the efficiency and effectiveness of the relevant policies in urban areas, to take the right step towards 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, SDG 11 has allocated an indicator for evaluating the local disaster risk reduction strategies. Flood risk assessment is an indicator which is addressed by all the sustainability methods addressed in this study. Moreover, ISO 37120 emphasises emergency response services and considers the assessment of natural-hazard-related deaths.

4.3.8.1 The Aligned Indicators with Different Approaches

The indicator of Natural and technological risks (I27) assesses the availability of procedural information in the event of natural and technological disasters. Risks are identified as the potential for events with negative consequences for people or the environment in general. Thus, the risks may be of natural origin or the result of human activity, which is called technological risks. For the evaluation of this indicator, the Environmental Impact Studies within the limits of the project's intervention area should be analysed. The Environmental Impact Studies of the area reveal if the natural and technological risks are identified for the location, and if any preventive measures and strategies to minimize natural or technological risks are implemented. Besides, SNTool Min version has three separate indicators for assessing the percentage of buildings exposed to major damage from fluvial flooding events, windstorms, and earthquakes in the intervention area of the project (A2.2, A3.1, A6.1). The intention of these indicators are to determine the vulnerability of buildings in the local area to these natural risks. Also, flood risk assessment alone, to determine the flood zone/zones of the site, is promoted by BREEAM-C (SE 03), and LEED-ND (SLL Prerequisite) as well. Interestingly, this issue is also supported by Level(s) through two indicators, including an indicator relevant to the ´ Increased risk of extreme weather ` (5.2) to make the building more resilient and resistant to extreme weather events when they occur (including the three main types of flooding: fluvial, pluvial and coastal), and another indicator for ´sustainable drainage` (5.3), which set out the steps to take, during the conceptual design stage, in order to embrace sustainable drainage options to reduce the chances of pluvial flood events in the local area and fluvial flood events downstream from occurring in the first place. The mentioned indicators are all aligned to indicator 27 of SBTool^{PT}_Urban.

Other indicators of the studied tools have very similar aspects and strategies to the developed indicator of SBTool^{PT}_Urban for category 8. More information relevant to the detailed description of the indicators can be found in Table 24.

4.3.8.2 Potential New Indicators for SBTool^{PT}_Urban

The indicators, adapting to climate change**,** promoted by BREEAM-C (SE 10)*,* is to ensure the development is resilient to the known and predicted impacts of climate change. The intention of this indicator is to understand the known and predicted impacts of climate change on the site, through the use of evidence from the local authority and statutory, regarding how risk will be managed and reduced. Besides, SNTool Minimum Version has promoted an indicator for assessment of the ´ predicted change in regional ambient summer temperatures´ (A1.1) in order to determine the vulnerability of buildings in the local area to coastal flooding events. Besides, Level(s) has an indicator about the ` protection of occupier health and thermal comfort` (5.1), by encouraging users to use projections for future climates in 2030 and 2050 under different "degree scenarios". This indicator measures the proportion of the year when building occupiers are comfortable with the summer thermal conditions inside a building and maintain pre-defined thermal comfort conditions during the cooling season. These three indicators can be merged in the first one, for BREEAM-C: adapting to climate change, which has a broader framework in comparison with others. However, this indicator is similar with indicator 27 of SBTool^{PT}_Urban Natural and technological risks, but the factors which are considered in this indicator are broader and included for more issues. This indicator has the potential to be added to indicator 27 of SBTool^{PT}_Urban or can be considered as a separate indicator (adapting to climate change) in category 8.

Table 23. The existing indicators of the category of security (C8), SBTool^{PT}_Urban (2018)

Indicators of the Category of Security, in SBTool^{PT}_U			
Tool	**Category**		**Indicators**
SBTool^{PT} Urban	Security	**26**	**Street Safety:** Recommendations for crime prevention measures.
		27	**Natural and technological risks:** Recommendations for the safety of the population and access to procedural information in the event of natural and technological disasters.

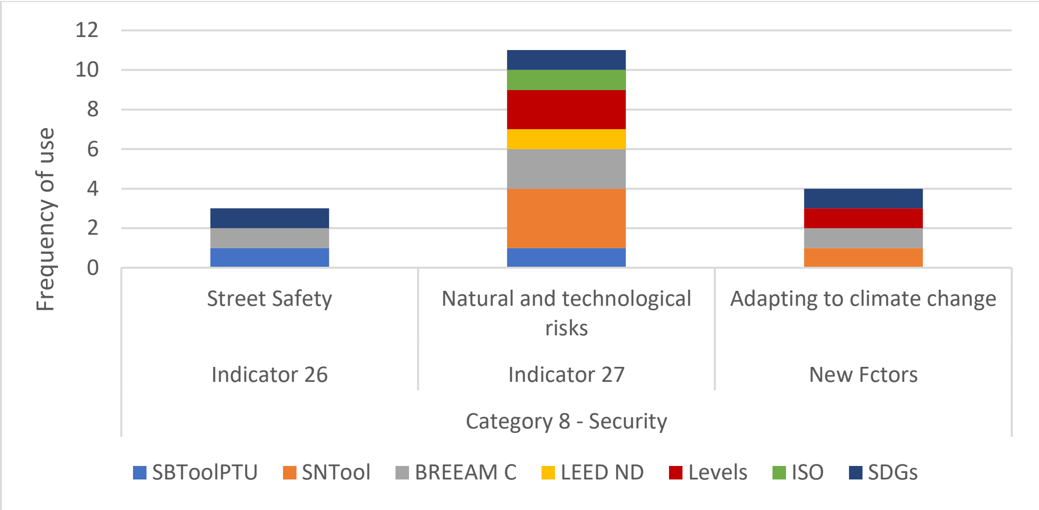


Figure 9. Frequency distribution of the indicators, relevant to the category of safety, in SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120 and SDGs, based on SBTool^{PT}_Urban (2018).

Table 24. Comparison analysis of the Category of Security (C8), of SBToolPT_Urban (2018) with SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120, SDGs of Agenda 2030.

Relevant Indicators of the Category of Security (C8)			SBTool^{PT}U IND
Tools	**Categories**	**Indicators**	
SNTool Min V.	Context and vulnerabilities	**A1.1 Predicted change in regional ambient summer temperatures:** To determine the vulnerability of buildings in the local area to coastal flooding events.	(5)
	Vulnerability to flooding events	**A2.2 Maximum percent buildings exposed to major damage from fluvial flooding events:** To determine the vulnerability of buildings in the local area to riverine flooding events.	27
	Vulnerability to windstorm events	**A3.1 Buildings subject to major damage from windstorm events:** To dete rmine the vulnerability of buildings in the local area to windstorm events.	27
	Vulnerability to earthquakes	**A6.1 Buildings subject to major damage from earthquakes:** To determine the vulnerability of buildings in the local area to local forest fire events.	27
Levels	Adaption and resilience to climate change	**5.1 Protection of occupier health and thermal comfort:** It encourages users to use projections for future climates in 2030 and 2050 under different "degree scenarios". This indicator measures the proportion of the year when building occupiers are comfortable with the summer thermal conditions inside a building, and to maintain pre-defined thermal comfort conditions during the cooling season.	(5)
		5.2 Increased risk of extreme weather: is about how to make the building more resilient and resistant to extreme weather events when they occur (including the three main types of flooding: fluvial, pluvial and coastal).	27
		5.3 Sustainable drainage: Set out the steps to take during the conceptual design stage to embrace sustainable drainage options to reduce the chances of pluvial flood events in the local area and fluvial flood events downstream from occurring in the first place.	27
BREEAM Communities	Transport and movement	**TM 02 – Safe and appealing streets:** To create safe and appealing spaces that encourage human interaction and a positive sense of place.	26
	Social and economic wellbeing	**SE 03 –Flood risk assessment:** To determine the flood zone/zones of the site and takes appropriate measures to reduce the risk of flooding to the development and the surrounding areas.	27
		SE 13 – Flood risk management: To avoid, reduce and delay the discharge of rainfall to public sewers and watercourses.	27
		SE 10 – Adapting to climate change: To ensure the development is resilient to the known and predicted impacts of climate change.	(5)

Table 24 (continued).

Relevant Indicators of the Category of Security (C8)			SBTool^{PT}U IND
Tools	**Categories**	**Indicators**	
LEED ND	Smart location and linkage (SLL)	**SLL Prerequisite – Floodplain avoidance:** To protect life and property, promote open space and habitat conservation, and enhance water quality and natural hydrologic systems.	27
ISO 37120	Safety	15.1 Number of firefighters per 100 000 population 15.3 Number of natural-hazard-related deaths per 100 000 population 15.7 Response time for emergency response services from initial call	27
SDGs	Goal 13	**Take urgent action to combat climate change and its impacts** 13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries 13.1.3 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies. 13.2 Integrate climate change measures into national policies, strategies, and planning 13.2 Integrate climate change measures into national policies, strategies, and planning 13.2.1 Number of countries that have communicated the establishment or operationalization of an integrated policy/strategy/plan which increases their ability to adapt to the adverse impacts of climate change, and foster climate resilience and low greenhouse gas emissions development in a manner that does not threaten food production (including a national adaptation plan, nationally determined contribution, national communication, biennial update report or other).	
	Goal 11	**Make cities and human settlements inclusive, safe, resilient and sustainable** 11.b.1 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015-2030.	

4.3.8.3 Identifying the EU Directives related to the New Potential Indicator

The relevant EU Directives, which define the importance of the potential new indicator is described as follow:

Regarding the assessment of Adapting to climate change and predicting changes in regional ambient summer temperatures, based on the implementation of REGULATION (EU) 2021/1119, establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 (‘European Climate Law’) (EC, 2021d)., the Member States shall ensure continuous progress in enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change in accordance with Article 7 of the Paris Agreement. Closing the climate disaster loss and risk data gap through (1) facilitating the recording, collecting and sharing of loss data through standards, (2) establishing a climate risk data governance framework and ensuring open access to data, (3) collecting data on direct economic losses, non-economic losses and slow-onset events, and aligning existing programmes and data sources, is measured in impact assessment report, for new EU Strategy on Adaptation to Climate Change (EC (2021e), (2021f)).

4.3.9 Analysing the Category of Amenities

The ninth category, the social dimension, of sustainability assessment of SBTool^{PT}_U focuses on the analysis of the issues related to amenities, based on the accessibility to urban public services for the daily life of inhabitants of a neighbourhood. This issue influences the inhabitant’s sense of place [22]. The provision of amenities enhances the advantages of economic prosperity and attracts the population in close proximity to them (Partridge et al., 2007). As shown in Table 25, this category is addressed through 3 indicators, including Proximity to services (I28), Recreational facilities (I29), and Local food production (I30). A snapshot of the data regarding the frequency distribution of the categorised indicators, in SBTool^{PT}_Urban (2018), SNTool (2020), BREEAM Communities (2012), LEED V4 (2018), ISO 37120 and SDGs is depicted in Figure 10. More information relevant to the detailed description of the indicators can be found in Table 26. The study identified that:

- **SNTool Min version** has three indicators, which have similar strategies to the indicator 28 of SBTool^{PT}_U;
- **BREEAM Communities** has one indicator that has similar strategies to the indicator 28 of SBTool^{PT}_U;
- **LEED-ND** has promoted four indicators that have similar strategies to the indicators of SBTool^{PT}_U;
- **Levels** does not support this category;

ISO 37120 highlighted the importance of the proximity of the neighbourhood to basic services and emergency response services. This is targeted by SDG 1 (1.1.4), which emphasised the proportion of the population living in households with access to basic services. For access to recreational facilities, ISO 37120, has promoted to assess the area of public outdoor recreation spaces and the budget that is allocated to cultural and sporting facilities by the municipalities. Besides these, ISO has allocated an indicator for assessing the urban agricultural area, and the amount of food produced locally, revealing the importance of local food production. Also, SDG 2 (2.3.2) supports this issue by examining the average income of small-scale food producers.

4.3.9.1 Potential New Indicators for SBTool^{PT}_Urban

For this category, based on the comparison of the indicators of the studied tools, the study did not find any potential new indicator to be added to SBTool^{PT}_Urban.

Table 25. The existing indicators of the category of mobility (C9), SBTool^{PT}_Urban (2018)

Mobility			
Tools	**Categories**	**No**	**Indicators**
SBTool^{PT} Urban	C9 - Mobility	**28**	**Proximity to services:** Recommendations to guarantee the inhabitants a set of diversified services on a scale of proximity to their homes.
		29	**Recreational facilities:** Recommendations to guarantee the inhabitants a set of quality leisure amenities on a scale of proximity to their homes.
		30	**Local food production:** Recommendations to guarantee city inhabitants access to fresh products, promoting community food production and contributing to improving the nutrition of residents and supporting the economic development of the place.

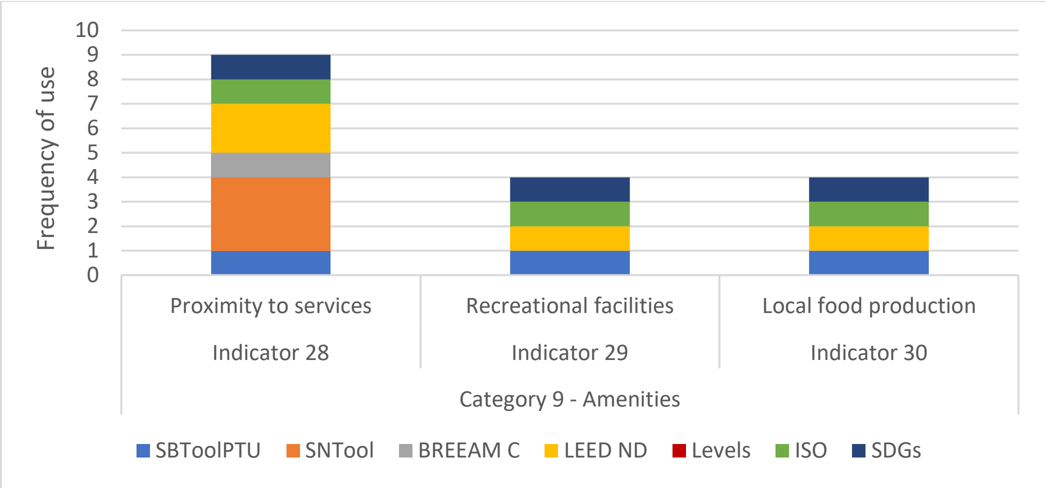


Figure 10. Frequency distribution of the indicators, relevant to the category of amenities, in SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120 and SDGs, based on SBTool^{PT}_Urban (2018).

Table 26. Comparison analysis of the Category of Amenities (C9) of SBToolPT_Urban (2018) with SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120, SDGs of Agenda 2030.

Relevant Indicators of the Category of Amenities (C9)			**SBTool^{PT}U IND**
Tools	**Categories**	**Indicators**	
SNTool Min V.	Public and private facilities and services	**G4.1 Proximity of key local consumer services to residential occupancies:** To determine the range of diverse consumer facilities in the local area.	28
		G4.2 Availability of a diverse range of retail goods and services in the local area: To determine the range of diverse consumer facilities in the local area.	28
		G4.3Availability and proximity of key local public services: To determine the accessibility and proximity of key local public services.	28
Levels		N/a	-
BREEAM Communities	Social and economic wellbeing	**SE 06 – Delivery of services, facilities, and amenities**: To ensure essential facilities are provided and that they are located within a reasonable and safe walking distance. Also, a monitoring and reporting process to regularly review the suitability and performance of services should be undertaken.	28
LEED ND	Neighborhood pattern and design (NPD)	**NPD Credit – Access to civic and public space:** To provide open space close to work and home that enhances community participation and improves public health.	28
		NPD Credit – Access to recreation facilities: To enhance community participation and improve public health by providing recreational facilities close to work and home that facilitate physical activity and social networking.	29
		NPD Credit – Local food production: Neighborhood Gardens, Community-Supported Agriculture, Proximity to Farmers Market.	30
		NPD Credit – Neighborhood schools: To integrate schools into the neighborhood, to promote community interaction and engagement.	28
ISO (37120)	Sport and culture	17.1 Number of cultural institutions and sporting facilities per 100 000 population (core indicator) 17.2 Percentage of municipal budget allocated to cultural and sporting facilities (supporting indicator)	28
	Recreation	14.2 Square meters of public outdoor recreation space per capita.	29
	Urban planning	21.4 Basic service proximity.	28
	Urban/local agriculture and food security	21.1 Green area (hectares) per 100 000 population 20.2 Amount of food produced locally as a percentage of total food supplied to the city.	29, 30

Table 26 (continued).

Relevant Indicators of the Category of Amenities (C9)			SBTool^{PT}U IND
Tools	**Categories**	**Indicators**	
SDGs	SDG 1	End poverty in all its forms everywhere. 1.4.1 Proportion of population living in households with access to basic services	
	SDG 2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture 2.3.2 Average income of small-scale food producers, by sex and indigenous status	

4.3.10 Analysing the Category of Mobility

The tenth category, the social dimension, of sustainability assessment of SBTool^{PT}_U focuses on the analysis of the issues related to mobility. Urban mobility basically concerns the ease of movement of people and goods through an adequate public transport network and increasing the quality of the local and intermodal connections, in order to reduce the use of the private individual vehicle. As shown in Table 27, this category is addressed through 3 indicators, including public transport(I31), pedestrian path accessibility(I32), and cycle path network(I33). A snapshot of the data regarding the frequency distribution of the categorised indicators, in SBTool^{PT}_Urban (2018), SNTool (2020), BREEAM Communities (2012), LEED V4 (2018), ISO 37120 and SDGs is depicted in Figure 11. More information relevant to the detailed description of the indicators can be found in Table 28. The study identified that:

- **SNTool Min version** has promoted three indicators that have similar strategies to the indicators of SBTool^{PT}_U;
- **BREEAM Communities** has promoted seven indicators that have similar strategies to the indicators of SBTool^{PT}_U;
- **LEED-ND** has promoted seven indicators that have similar strategies to indicators of SBTool^{PT}_U;
- **Level(s)** does not provide indicators with similar issues for this category.

Therefore, this is evident that the concept of urban mobility is broad. Urban mobility involves intermodal articulations, where different means of transport, alternative transport options, and efficient accessibility must be planned in an integrated way. A sustainable urban mobility plan can be designed to establish the mobility needs of people and businesses in cities to improve the quality of life for the inhabitants. This approach is promoted by the studied tools and supported by the SDGs, focusing on estimating the proportion of the population that has convenient access to public transport, and passenger and freight volumes by mode of transport, respectively according to SDG 11 (11.2.1) and SDG 9 (9.1.2). Moreover, ISO considered the kilometres of the public transport system as a core indicator and proving accessibility to public transit in close proximity to living areas, and the percentage of commuters using a travel mode to work as the supporting indicators.

Table 27. The existing indicators of the category of Mobility (C10), SBTool[PT]_Urban (2018)

Mobility			
Tools	**Categories**	**No**	**Indicators**
SBTool[PT] Urban	C10 - Mobility	**31**	**Public Transport:** Recommendations to assess the public transport road network regarding the accessibility, and quality. Moreover, to encourage the use of clean renewable energies in public transport.
		32	**Pedestrian Path Accessibility:** Recommendations to promote mobility and pedestrian safety and the accessibility of people with reduced mobility, supporting public health by encouraging utilitarian and recreational physical activity and also encouraging the use of non-polluting means of transport.
		33	**Cycle Path Network:** Recommendations to promote the quality cycle path network.

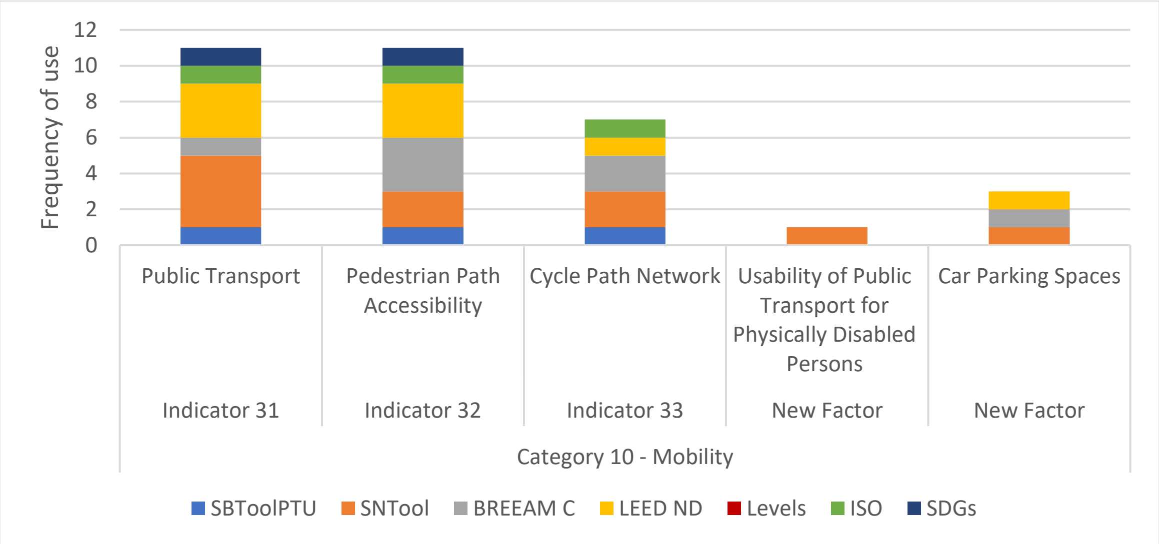


Figure 11. Frequency distribution of the indicators, relevant to the category of mobility, in SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120 and SDGs, based on SBTool[PT]_Urban (2018).

Table 28. Comparison analysis of the Category of Mobility (C10) of SBTool[PT]_Urban (2018) with SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120, SDGs of Agenda 2030.

Relevant Indicators of the Category of Mobility (C10)			SBTool[PT]U IND
Tools	**Categories**	**Indicators**	
SNTool Min V.	Transportation Infrastructure	**B2.1 Walking distance to public transport for area residents:** To identify typical walking distances to public transport stops.	31
		B2.2 Walking distance to public transport for area workers and students: To identify the typical walking distance from key educational or workplaces to the nearest public transport stop.	31
		B2.4 Extent and connectivity of bicycle paths separated from vehicular traffic: To assess the aggregate length of bicycle paths separated from vehicular traffic in the local area.	33
		B2.6 On-street and indoor car parking spaces relative to local population: To determine the ratio of on-street and indoor car parking spaces relative to the total resident population of the local area.	(1)
	Traffic and Mobility Services	**G2.1 Access to a public transport service:** To determine the performance of the public transportation system.	31
		G2.4 Quality of pedestrian and bicycle network: To promote cycling and walking as an alternative to vehicle use.	32, 33

Table 28 (continued).

Relevant Indicators of the Category of Mobility (C10)			SBTool^{PT}U IND
Tools	**Categories**	**Indicators**	
SNTool Min V.	Safety and Accessibility	**G1.4 Ease of access to and use of public transport for physically disabled persons:** To facilitate the acess to public transport by physically disabled persons.	32 (2)
Levels		N/a	-
BREEAM Communities	Social and economic wellbeing	**SE 07 – Public realm:** To ensure the design of the public realm to encourage connectivity into and throughout the development.	32, 33
		SE 12 – Local parking: Recommendations for public parking and residential parking.	(1)
		SE 15 – Inclusive design: To create an inclusive community by enhancing accessibility for as many current and future residents as possible.	32
	Transport and movement	**TM 01 – Transport carbon emissions:** To establish appropriate alternative transport options for the development.	31
		TM 03/05 – Cycling network and facilities: To promote cycling as an alternative to vehicle use by providing a safe and efficient cycle network.	33
		TM 04 – Access to public transport: To ensure a safe and convenient pedestrian route from building entrance to a compliant transport node.	32
		TM 06 – Public transport facilities: recommendations for occupants and potential visitors and their accessibility needs, expected number of users at each public transport stop, existing facilities, provision of facilities.	31
LEED ND	Smart location and linkage (SLL)	**LT Credit – Access to quality transit:** To encourage development in locations that have multimodal transportation choices or otherwise reduced motor vehicle use.	31
		LT Credit – Bicycle facilities: To promote cycling and transportation efficiency and reduce vehicle distance travelled.	33
		LT CREDIT: Reduced parking footprint: To minimize the environmental harms associated with parking facilities.	(1)
	Neighborhood pattern and design (NPD)	**NPD Credit – Transit facilities:** To encourage transit use and reduce vehicle distance travelled by providing safe, convenient, and comfortable transit waiting areas.	31
		NPD Credit – Transportation demand management: To encourage multimodal travel.	31
		NPD Credit – Walkable streets: Recommendations for Facades and Entries, Ground-Level Use and Parking, Design Speeds for Safe Pedestrian and Bicycle Travel, Sidewalk Intrusions.	32 32
		NPD Credit – Connected and open community: Recommendations for Surrounding Connectivity, and internal connectivity. **NPD Credit – Tree-lined and shaded streetscapes:** Recommendations for tree-lined blocks, shaded sidewalks.	32
ISO 37120	Transportation	19.1 Kilometres of public transport system per 100 000 population 19.2 Annual number of public transport trips per capita 19.3 Percentage of commuters using a travel mode to work other than a personal vehicle 19.4 Kilometres of bicycle paths and lanes per 100 000 population 19.6 Percentage of population living within 0,5 km of public transit running at least every 20 min during peak periods 19.7 Average commute time	31, 32, 33
SDGs	Goal 9	**Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation** 9.1.1 Proportion of the rural population who live within 2 km of an all-season road. 9.1.2 Passenger and freight volumes, by mode of transport.	To all
	Goal 11	**Make cities and human settlements inclusive, safe, resilient and sustainable.** 11.2.1 Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities.	

4.3.10.1 The Aligned Indicators with Different Approaches

The indicator of Pedestrian Path Accessibility (I32) assesses mobility and pedestrian safety and the accessibility of people with reduced mobility, supporting public health by encouraging utilitarian and recreational physical activity, and encouraging the use of non-polluting means of transport. Based on the verification checklist of indicator 32, it evaluates the effectiveness of path width, facilities, and equipment along the paths (e.g., streetlights, bins, waiting facilities), accessibility and connectivity of paths (also to people with limited mobility), and security and protection of pathways (e.g., effective turn radius of intersections, protection guards for separating the pedestrian paths from traffic routes). SNTool Min version has an indicator for assessing of Accessibility and usability of key buildings by physically disabled persons (G1.1) which assesses the ability of residents, workers, or visitors with physical disabilities to be able to have physical access to the key buildings. This indicator is already within the framework of indicator 32 of SBTool^{PT}_Urban and is developed by the local building regulation in Portugal.

Other indicators of the studied tools, except for the indicators described in the next section, have very similar aspects and strategies to the developed indicator of SBTool^{PT}_Urban for category 10. More information relevant to the detailed description of the indicators can be found in Table 28.

4.3.10.2 Potential New Indicators for SBTool^{PT}_Urban

The indicator of Public Transport (I31) assesses the public transport road network regarding accessibility, and quality. Moreover, to encourage the use of clean renewable energies in public transport. Also, based on the verification checklist of indicator 31, it evaluates types of public transport in the urban area, the number of stops, the average frequency of daily passage and services during rush hours, the quality of available public transport stops, and the existence of car parks on the outskirts with access to public transport. SNTool Min version has an indicator for evaluating the Ease of access to and use of public transport for physically disabled persons (G1.4) which assesses the features of public transport relevant to facilitated access for physically disabled persons, such as kneeling buses and wide entries. Accessibilities cover a wide range of issues from support products to access to buildings and transports. For the case of this indicator, the main purpose is the issue of access conditions for the transport of disabled persons and persons with reduced mobility. This factor has the potential to be added to the verification list of indicators 31.

Moreover, regarding the availability of car parking, the verification checklist of indicator 31 mentioned the existence of car parks on the outskirts with access to public transport. Indicator, On-street and indoor car parking spaces, promoted by SNTool (B2.6) and BREEAM-C (SE 12), are intended to ensure the number of on-street and indoor car parking spaces are appropriate for the expected users and well-integrated into the development of the local area. Also, LEED-ND encouraged to minimizing the environmental harms associated with parking facilities, including automobile dependence, land consumption, and rainwater runoff. This indicator has the potential to be added as an additional factor(s) to the verification list for indicator 31.

4.3.10.3 Identifying the EU Directives related to the New Potential Indicator

The relevant EU Directives, which define the importance of the potential new indicators are described as follows:

- The Council of the European Union and the European Parliament, through regulation 181/2011 (EC, 2011b), created rights for passengers when travelling by Bus and Coach. The regulation mentioned that terminal managing bodies shall, where appropriate through their organisations, establish, or have in place, non-discriminatory access conditions for the transport of disabled persons and persons with reduced mobility. But, Article 18, of the same document added that the Member States may exempt **domestic regular services** from the application of all or some of the provisions, and instead the level of protection of disabled persons and persons with reduced mobility can be kept under the national rules. Therefore, this factor obligated the assistance provided to disabled persons and persons with reduced mobility at designated terminals only (EC. 2011b). Based on the UN human rights (2016), Portugal had not considered the issue of accessibility for people with disabilities in some forms of the provisions of the convenient in their National Disability Strategy, offering the opportunity for Portugal to make progress in the areas of mobility, employment, education, and other opportunities for the most vulnerable persons. This raised a question regarding: what measures had been taken to monitor the implementation of the legislation on the Rights of Persons with Disabilities and the action plan adopted by the Government. However, with regard to discrimination, the delegation said that the Portuguese Constitution contained a number of provisions aimed at regulating the rights of persons with disabilities. The Article 8 stated that the provisions of international treaties ratified by Portugal were directly applicable. Article 13 enshrined the principle of equality, and Article 71 referred explicitly to persons with disabilities. The law prohibiting discrimination on the ground of disability set out penalties. The Criminal Code had 14 different provisions in which discrimination was set out as a component of the criminal offense, including inter alia for crimes of murder, neglect, qualified physical abuse, violence, abduction, or trafficking, which made the penalty stiffer. The National Institute for rehabilitation monitored the implementation of the anti-discrimination legislation.
- The European Commission has undertaken a row of initiatives with the aim to support and coordinate the provision of adequate parking, and information and reservation services for safe and secure parking places only for trucks and commercial vehicles (EC, 2013). However, there are explorations on how parking requirements in new urban neighbourhoods should be designed to reduce building costs while also promoting sustainable mobility, based on the European Horizon 2020 project, Park4SUMP, a project exploring parking management across 15 European countries. This factor is already mentioned in indicator 31. However, the necessity of accessibility to other types of parking are not mentioned in EU Directives, but accessibility to green parking facilities can help sustainability in the cities. The incentive is that as vehicles are present so is the practice of searching for a good parking space.

4.3.11 Analysing the Category of Local and Cultural Identity

The eleventh category, the social dimension, of sustainability assessment of SBTool^{PT}_U focuses on the analysis of the issues related to Local and Cultural Identity. The objective of this category is to analyse the cultural activities and recreational opportunities of the area, which contribute to the attractiveness of the region and add to the sense of place and belonging. Sense of place is often intricately linked to history, cultural identity, and social relations (Ryfield et al., 2019), which is important to have better mental health and psychological well-being (Cui et al., 2021). Moreover, the right to sufficient housing, according to the United Nations Committee on Economic, Social, and Cultural Rights, should be understood as the right to live somewhere in safety, peace, and dignity (UN-habitat, 2015). As shown in Table 29, this category is addressed through 3 indicators, including Access to Public Spaces (I34), Valuing Heritage (I35), and social inclusion and integration (I36). A snapshot of the data regarding the frequency distribution of the categorised indicators, in SBTool^{PT}_Urban (2018), SNTool (2020), BREEAM Communities (2012), LEED-ND (2018), ISO 37120 and SDGs is depicted in Figure 12. More information relevant to the detailed description of the indicators can be found in Table 30. The study identified that:

- **SNTool Min version** has promoted two indicators that have similar strategies to the indicator 36 of SBTool^{PT}_U;
- **BREEAM Communities** has promoted eight indicators that have similar strategies to the indicators of SBTool^{PT}_U;
- **LEED-ND** has promoted five indicators that have similar strategies to indicators of SBTool^{PT}_U;
- **Level(s)** does not provide indicators with similar issues for this category.

In addition, SDG 11 asked governments to make cities and human settlements inclusive, safe, resilient, and sustainable, by promoting approaches to protecting heritage, cultural and natural identity, providing adequate housing, etc. Besides 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 encouraged for all learners to acquire the knowledge and skills needed to promote sustainable development and sustainable lifestyles, human rights, gender equality, citizenship and appreciation of cultural diversity and culture's contribution to sustainable development, etc. Therefore, SDGs and ISO 37120 are aligned to the indicators of category 11, defined the strategies to monitor the local and cultural identity of the neighbourhoods, which can help decision-makers to define the impacts of the current situation in a neighbourhood area.

4.3.11.1 Potential New Indicators for SBTool^{PT}_Urban

For this category, based on the comparison of the indicators of the studied tools, the study did not find any potential new indicator to be added to SBTool^{PT}_Urban.

Table 29. The existing indicators of the category of Local and Cultural Identity (C11), SBToolPT_Urban (2018).

Local and Cultural Identity			
Tools	**Categories**		**Indicators**
SBTool^{PT} Urban	C11 - Local and Cultural Identity	**34**	**Public Spaces:** Recommendations for assessing the availability and quality of existing or planned public spaces.
		35	**Valuing Heritage:** Recommendations for the valorisation of the heritage, whose objective is to promote the maintenance of the built and natural historical heritage of the place, and to promote public use and boost the heritage.
		36	**Social Inclusion and Integration:** Recommendations for social integration and inclusion aims to promote affordable housing for all people and promoting local identity and a sense of community.

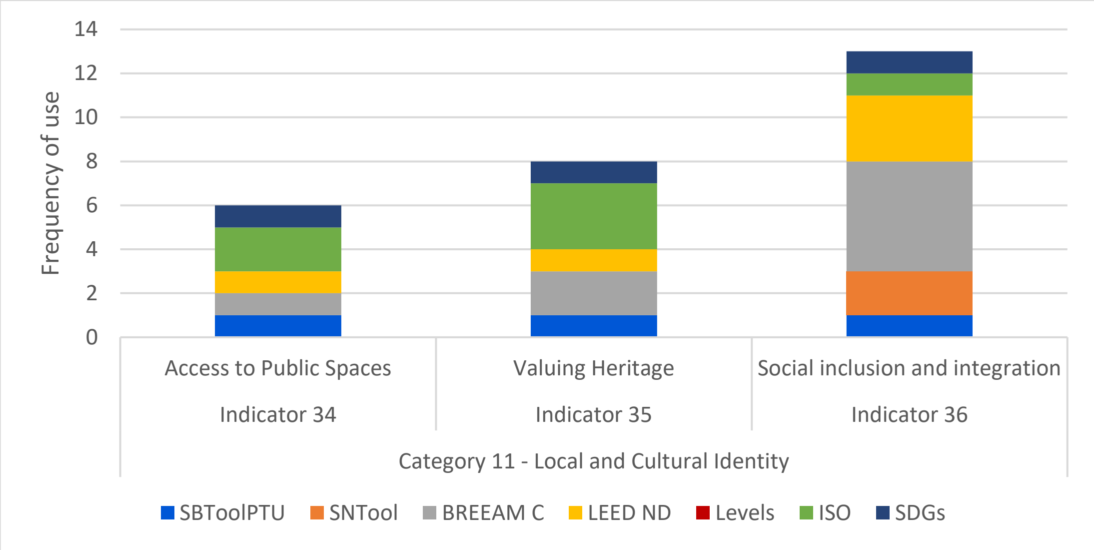


Figure 12. Frequency distribution of the indicators, relevant to the category of local and cultural identity, in SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120 and SDGs, based on SBTool^{PT}_Urban (2018).

Table 30. Comparison analysis of the Category of Local and Cultural Identity (C11), of SBToolPT_Urban (2018) with SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120, SDGs of Agenda 2030.

Relevant Indicators of the Category of Local and Cultural Identity (C11)			**SBTool^{PT}U IND**
Tools	**Categories**	**Indicators**	
SNTool (Min V.)	Economic Structure and Value	**C1.2 Affordability of housing rental:** To assess the affordability of housing rental property for low-income residents in the local area.	36
	Cost and Investment	**C3.1 Provision for social housing units:** To estimate whether funding for social housing is adequate to meet the housing needs of low-income groups in the local area.	36
Levels		N/a	
BREEAM Communities	Social and economic wellbeing	**SE 02 – Demographic needs and priorities:** To ensure that the development plans for the provision of housing, services, facilities, and amenities is based upon the local demographic trends and priorities.	36
		SE 05 – Housing provision: To minimize social inequalities and foster a socially inclusive community by ensuring appropriate housing provision within the development, based on the needs in the local area for different housing type and tenure, availability of affordable rented, social rented and intermediate affordable housing.	36
		SE 07 – Public realm: To design the social spaces to strengthen the local identity of the area.	35
		SE 11 – Green infrastructure: To ensure access to high quality space in the natural environment or urban green infrastructure for all.	34
		SE 14 – Local vernacular: Recommendations to reinforce the local identity in a number of aspects (e.g., use of: local materials, local building forms, heights and architectural features, inclusion or retention of historic features, local or regional plant species, public art, etc.)	35
		SE 17 – Training and skills: To ensure that the development contributes to the local area by enhancing skills and training opportunities that would be beneficial to the local area.	36
	Governance	**GO 02 – Consultation and engagement:** To ensure the needs, ideas and knowledge of the community and key stakeholders are used to improve the quality and acceptability of the development throughout the design process.	36
		GO 04 – Community management of facilities: To support communities in active involvement in developing, managing and/or owning selected facilities.	36

Table 30 (continued).

Relevant Indicators of the Category of Local and Cultural Identity (C11)			SBTool^{PT}U IND
Tools	**Categories**	**Indicators**	
LEED ND	Neighborhood pattern and design (NPD)	**NPD Credit: Access to civic and public space:** To provide open space close to work and home that enhances community participation and improves public health.	34
		NPD Credit – Housing types and affordability: Recommendations for promoting diversity of housing types and affordable housing to promote socially equitable and engaging neighborhoods.	36
		NPD Credit – Visitability and universal design: To increase the proportion of areas usable by a wide spectrum of people, regardless of age or ability.	36
		NPD Credit – Community outreach and involvement: To encourage responsiveness to community needs by involving the people who live or work in the community in project design and planning and in decisions about how the project should be improved or changed over time.	36
	Green infrastructure and buildings (GIB)	**GIB Credit – Historic resource preservation and adaptive reuse:** To respect local and national landmarks and conserve material and cultural resources by encouraging the preservation and adaptive reuse of historic buildings and cultural landscapes.	35
ISO (37120)	Housing	12.1 Percentage of city population living in inadequate housing 12.2 Percentage of population living in affordable housing	36
	Recreation	14.2 Square metres of public outdoor recreation space per capita	34
	Sport and culture	17.1 Number of cultural institutions and sporting facilities 17.2 Percentage of municipal budget allocated to cultural and sporting facilities	34
		17.3 Annual number of cultural events per 100 000 population (e.g., exhibitions, festivals, concerts).	35
	Urban planning	21.1 Green area (hectares) per 100 000 population 21.3 Jobs–housing ratio	34, 36
SDGs	Goal 4	**Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all** 4.4 By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship. 4.7 By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development.	36
	Goal 11	**Make cities and human settlements inclusive, safe, resilient and sustainable** 11.a Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning. 11.a.1 Number of countries that have national urban policies or regional development plans that (*a*) respond to population dynamics; (*b*) ensure balanced territorial development; and (*c*) increase local fiscal space. 11.1.1 Proportion of urban population living in slums, informal settlements or inadequate housing. 11.4.1 Total per capita expenditure on the preservation, protection and conservation of all cultural and natural heritage, by source of funding (public, private), type of heritage (cultural, natural) and level of government (national, regional, and local/municipal) 11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities	3

4.3.12 Analysing the Category of Employment and Economic Development

The twelfth category, the social dimension, of sustainability assessment of SBTool^{PT}_U focuses on the analysis of the issues related to Employment and economic development. Economic development is one of the variables that determines success in the development of a region, according to the Human Development Table (HDI), which is the brainchild of UNDP, analysing human development achievements by several key quality-of-life (Afkarina et al., 2019). The economic analysis should be focused on the local government's priorities, represent the size and influence of the development, and consider the sur-rounding area that is likely to be influenced by it (BREEAM Communities, 2012). As shown in Table 31, this category is addressed through 3 indicators, including Economic Viability (I37), Local Economy (I38), and Employability (I39). A snapshot of the data regarding the frequency distribution of the categorised indicators, in SBTool^{PT}_Urban (2018), SNTool (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120 and SDGs is depicted in Figure 13. More information relevant to the detailed description of the indicators can be found in Table 32. The study identified that:

- **SNTool Min version** has promoted two indicators that have similar strategies to the indicator 36 of SBTool^{PT}_U;
- **BREEAM Communities** has promoted eight indicators that have similar strategies to the indicators of SBTool^{PT}_U;
- **LEED-ND** has promoted five indicators that have similar strategies to indicators of SBTool^{PT}_U;
- **Level(s)** does not provide indicators with similar issues for this category.

SDG 8 encourages entrepreneurship and job creation, achieving full and productive employment, and decent work, for all women and men by 2030. The first step towards entrepreneurship is to focus on the unique environmental, economic, and social features of sustainability, capable of promoting the local economy through the planned extensive strategies. Therefore, to implement appropriate strategies, it is vital to identify the factors which influence the local economy of the region.

4.3.12.1 Potential New Indicators for SBTool^{PT}_Urban

For this category, based on the comparison of the indicators of the studied tools, the study did not find any potential new indicator to be added to SBTool^{PT}_Urban.

Table 31. The existing indicators of the category of employment and economic development (C12), SBTool^{PT}_Urban (2018)

Employment and Economic Development			
Tools	**Categories**		**Indicators**
SBTool^{PT} Urban	Employment and Economic Development	**37**	**Economic Viability:** Recommendations to promote and optimize initial costs based on the evaluation of operating and maintenance costs, during the operation phase of the urban area under analysis. (cost-effectiveness, economic feasibility)
		38	**Local Economy:** Recommendations to promote the local economy through the diversification of goods and services, enhancing internal circulation.
		39	**Employability:** Recommendations for promoting local employment, through the creation of jobs.

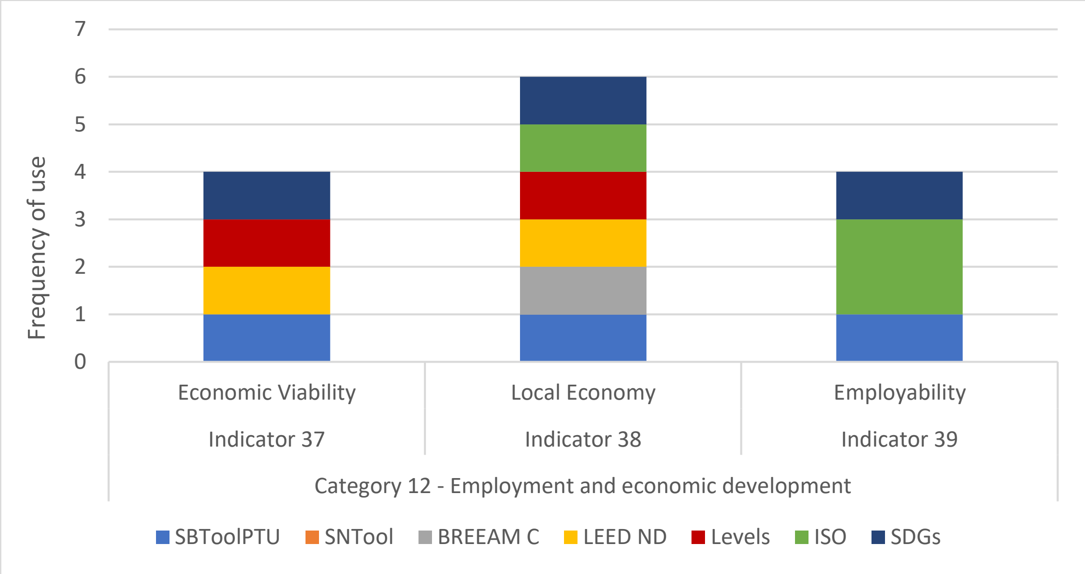


Figure 13. Frequency distribution of the indicators, relevant to the category of economy, in SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120 and SDGs, based on SBToolPT_Urban (2018).

Table 32. Comparison analysis of the Category of Employment and Economic Development (C12), of SBToolPT_Urban (2018) with SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120, SDGs of Agenda 2030.

Relevant Indicators of the Category of Employment and Economic Development (C12)			**SBToolPTU IND**
Tools	**Categories**	**Indicators**	
SNTool Min V.		N/A	
Levels	Optimised life cycle cost and value	**6.1 Life cycle costs (€/m²/yr):** It measures all building element costs incurred at each life cycle stage of a project for the reference study period and, if defined by the client, the intended service life.	37
		6.2 Value creation and risk factors: It measure and track the positive influence of improved sustainability performance on a property financial valuation and/or a financial risk rating.	38
BREEAM Communities	Social and economic wellbeing	**SE 01 – Economic impact:** Considering the opportunities to attract inward investment to the area in the economic study or local/sub-regional economic strategies of the site.	38
LEED ND	Smart location and linkage (SLL)	**SLL Credit – Housing and jobs proximity:** To encourage balanced communities with a proximate housing and employment opportunities.	38
	Regional priority	**RP Credit: Regional priority:** To provide an incentive for the achievement of credits that address geographically specific environmental, social equity, and public health priorities, identified by the USGBC regional councils and chapters as having additional regional importance for the project's region.	37
ISO (37120)	Economy	5.2 Assessed value of commercial and industrial properties as a percentage of total assessed value of all properties.	38
		5.5 Number of businesses per 100 000 population	39
	Finance	9.3 Own-source revenue as a percentage of total revenues 9.4 Tax collected as a percentage of tax billed	39
SDGs		**Goal 8:** Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all 8.1.1 Annual growth rate of real GDP per capita	To all

4.3.13 Analysing the Category of Buildings

The thirteenth category, provided for attribution of the extra points, refer to the analysis of the issues related to Buildings. This indicator aims to reward the construction of sustainable buildings and aims to promote sustainability at the building level. Sustainability at the building level aims at efficiency in the consumption of resources in the different phases of the building's life cycle, maximizing the comfort of its inhabitants. Sustainable buildings are designed to reduce the overall impact of the built environment on human health and the natural environment through:

- Efficient use of energy, water, materials, and other resources,
- Protection of occupants 'health and improvement of workers' productivity,
- Reduction of waste, pollution, and environmental degradation.

In order to comply with the indicator referring to sustainable buildings, regulations that require the assessment and certification of the sustainability of the constructed building is necessary, through any recognized assessment and certification system. The studied tools have the possibility to assess and certify the buildings, through their building scale assessment methods, including:
SBTool (Sustainable Building Tool), a generic system to assess the performance in terms of the sustainability of buildings and projects, BREEAM (Building Research Establishment Environmental Assessment Method), method of assessment and environmental classification of buildings created in the United Kingdom, LEED (Leadership in Energy and Environmental Design) is a sustainable building assessment tool that covers the entire life cycle of the building.
However, for this category, based on the comparison of the indicators of the studied tools , shown in Table 33, there is not any potential new indicator to be added to SBTool^{PT}_Urban.

Table 33. Comparison analysis of the existing indicators of the category of Building (C13), of SBToolPT_Urban (2018) with SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120, SDGs of Agenda 2030.

Relevant Indicators of the Category of Buildings (C13)			SBTool^{PT}U IND
Tools	**Categories**	**Indicators**	
SBTool^{PT}U	Sustainable Building	To reward the construction of sustainable buildings and aims to promote sustainability at the building level.	40
SNTool Min V.	-	N/A	
BREEAM Communities	Designing the details	**RE 04 – Sustainable buildings:** To increase the sustainability of all buildings within the development.	40
LEED ND	Green infrastructure and buildings (GIB)	**GIB Prerequisite - Certified green building:** To encourage the design, construction, and retrofit of buildings using green building practices.	40
Levels		**All the indicators of Level(s) are compatible with this indicator.**	40
ISO (37120)	-	N/A	
SDGs	Goal 3 Goal 7 Goal 8 Goal 9 Goal 11 Goal 12 Goal 13 Goal 15 Goal 17	Good health and well being Affordable and vlean energy Decent work and economic growth Industry, innovation, and infrastructure Sustainable cities and communities Responsible consumption and production Climate action Life on land Partnerships	40

4.3.14 Analysing the Category of Environment

The fourteenth category, provided for attribution of the extra points, focuses on the analysis of the issues related to Environmental. This indicator refers to the implementation of Information and Communication Technologies (ICT), from a Smart City perspective, aims to promote the integrated management of the various environmental aspects of the place, for a constant improvement of the urban environment. As shown in Table 34, this category addressed through the indicator, Environmental Management (I41). A snapshot of the data regarding the frequency distribution of the categorised indicators, in SBTool^{PT}_Urban (2018), SNTool (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120 and SDGs is depicted in Figure 14. The study identified that:

- **SNTool Min version** has promoted two indicators that have similar strategies to the indicator 36 of SBTool^{PT}_U;
- **BREEAM Communities** has promoted eight indicators that have similar strategies to the indicators of SBTool^{PT}_U;
- **LEED-ND** has promoted five indicators that have similar strategies to indicators of SBTool^{PT}_U;
- **Level(s)** does not provide indicators with similar issues for this category.

For this category, based on the comparison of the indicators of the studied tools, the study did not find any potential new indicator to be added to SBTool^{PT}_Urban.

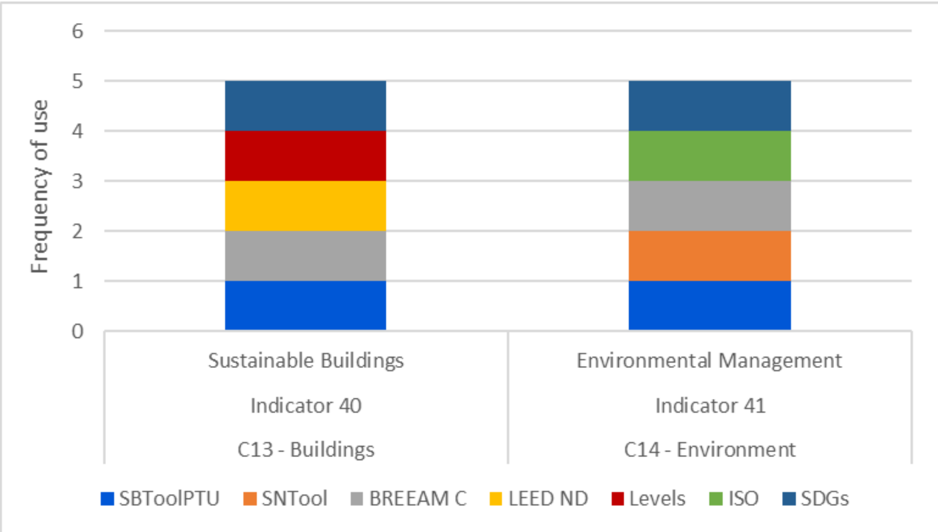


Figure 14. Frequency distribution of the indicators, relevant to the categories of Building and Environment, in SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120 and SDGs, based on SBTool^{PT}_Urban (2018).

Table 34. Comparison analysis of the existing indicators of the category of Environment (C14), of SBToolPT_Urban (2018) with SNTool (2020), BREEAM-C (2012), LEED-ND (2018), Level(s), ISO 37120, SDGs of Agenda 2030.

Relevant Indicators of the Category of Environment (C14)			**SBTool^{PT}U IND**
Tools	**Categories**	**Indicators**	
SBTool^{PT}U	Environmental management	To encourage the implementation of Information and Communication Technologies (ICT), from a Smart City perspective, aims to promote the integrated management of the various environmental aspects of the place.	41
SNTool (Min V.)	Other local infrastructure	**B3.4 Availability and access to a public telecommunications system:** Availability and access to a public telecommunications system for all permanent buildings in the area.	41
Levels	-	N/A	
BREEAM Communities	Social and economic wellbeing	**SE 09 – Utilities:** To provide easy access to site service and communications infrastructure, with minimal disruption and need for reconstruction, and to allow for future growth in services. The service is included gas, electricity, water/sewerage, telecommunications/internet, heat and cooling (where relevant).	41
LEED ND	-	N/A	
ISO 37120	Telecommunication	18.1 Number of internet connections per 100 000 population 18.2 18.2 Number of mobile phone connections per 100 000 population 17.3 Number of landline phone connections per 100 000 population	41
SDGs	Goal 9	Industry, innovation, and infrastructure	41

4.4 Finalising, Prerequisite, and calculation methods available for the potential new factors and indicators

Based on the evaluation and comparison of the studied tools, the study found 7 new indicators which have the potential to be added as a new factor to the existing indicators or to be used as new indicators. The concluded indicators of the survey are shown in Table 35. To ascertain the importance of the selected indicators, their coverage by the EU Directive analysed. The final list of the proposed new factors and indicators are:

1. Conservation of land – A potential new indicator
2. Construction activity pollution prevention – A potential new factor
3. District heating and cooling – A potential new factor
4. GHG emissions from energy embodied in construction materials – A potential new factor
5. Adapting to climate change – A potential new factor
6. Usability of public transport for physically disabled persons – A potential new factor
7. car parking spaces – A potential new factor

The intention and main issues of the proposed indicator, and factors are defined in the next sections.

Table 35. The proposed potential new indicators, and their identified relevancy with EU Directives.

Potential New Indicators		Relevant EU Directives
1	Conservation of land	Habitat Directives 92/43/EEC, Roadmap to a Resource Efficient Europe, European Green Deal.
2	Construction activity pollution prevention	Integrated Pollution Prevention and Control (IPPC) Directive 2008/1/EC, Towards Zero Pollution for Air, Water and Soil Directive SWD (2021) 140 final, Horizon Europe Cities Mission.
3	District heating and cooling	Energy performance of buildings Directive 2010/31/EU.
4	GHG emissions from energy embodied in construction materials	Energy performance of buildings COM (2021) 802 final 2021/0426.
5	Adapting to climate change	The framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law'), EU Strategy on Adaptation to Climate Change (ADAPT) 2022-2024.
6	Usability of public transport for physically disabled persons	N/a (but mandated in the relevant national regulations)
7	car parking spaces	N/a (but mandated in the relevant national regulations)

4.4.1 Analysing the issue of Conservation of Land, as a new potential indicator

Conservation of Land - To determine the proportion of undeveloped land, considered to be of value for ecological or agricultural purposes, that remains undeveloped.

Most urban areas exist in a state of continuing development and re-development, with the building stock and infrastructure undergoing concurrent construction, operation, renovation, and demolition activities. In many cases development or re-development is inefficient in terms of the use of land that would otherwise be valuable for ecological or agricultural purpose. Land conservation is the process of protecting natural land and returning developed land to its natural state. As humans develop and harm different ecosystems, a variety of techniques are needed to try to save the environments and protect the remaining land. Preservation and restoration are two techniques of land conservation. Preservation of the environment means that lands and their natural resources should not be consumed by humans and should instead be maintained in their pristine form. Preservationists strongly believe that humans can have access to the land but should only utilize it for its natural beauty and inspiration. Beside this, restoration is the process of returning ecosystems and communities to their original natural conditions. In order to restore an ecosystem, scientists must first examine the current environment and do research to determine the historical conditions of the ecosystem. They want to determine what the environment was like before it was altered by humans. Once they have assessed the environment, scientists will develop methods to try to bring the area back to its original state. This often includes introducing native animals, planting native plants, restoring waterways to their natural path, and removing human infrastructure (Land Conservation, 2014).

SBTool^{PT}-Urban method has already covered the issue of restoration of lands and ecosystems. But, the study found that the issue of preservation of the land is ignored in the tool. In this context, the amount of such land that remains undeveloped is useful information in developing strategies to ensure efficient urban development, while ensuring the integrity of ecological and agricultural services (Andrea Moro, 2019). This issue is highlighted in European's biodiversity strategy based on the conservation of natural habitats and of wild fauna and flora towards the targets set for 2030, and addressed in Roadmap to a Resource Efficient Europe, and European Green Deal as well. Therefore, the study proposed the adaption of the indicator for "Conservation of Land" by the SBToolPT-Urban.

The assessment method of this indicator is described as follows:

1. Determining the area of the neighbourhood.
2. Determining the undeveloped area of land that is considered by authorities to be of ecological and agricultural value.
3. Calculating the ratio between the undeveloped land with ecological or agricultural value and the area of the neighbourhood.

Description	Unit	Data source
Area of undeveloped land with ecological or agricultural value/area of the neighborhood	%	Urban area thematic map

The necessary elements for the evaluation are:
1. General plan of the urban area or urban planning project,
2. Regulation of the local urbanization plan,
3. Environmental Impact Studies developed for the project's intervention area,
4. Strategic Environmental Assessment (SEA).

The specifications of the issue are:

1. Only areas with recognized ecological or agricultural value, also in the case of the reconverted areas, must be taken into account,
2. The area of the neighbourhood is the area included within the perimeter selection,
3. Parks and squares are not considered undeveloped land,
4. Definition of agricultural value: an area that is intended for agricultural objectives (food, forage, etc.),
5. Definition of ecological value: an area that has an ecological value because provides support to native life forms, making up natural ecosystems.

4.4.2 Analysing the Issue of Construction Activity Pollution Prevention, as a New Potential Factor

Construction activity pollution prevention - To reduce pollution from construction activities by controlling soil erosion, waterway sedimentation, and airborne dust.

This indicator is already within the scope of Strategic Environmental Assessment (SEA), which is encouraged by indicator 12 of SBTool^{PT}_Urban. Based on SBTool^{PT}-Urban, the Project's Plans should include the objectives and targets of an Environmental Monitoring Plan, for assessing the related identified aspects and carrying out a new survey of potential impacts associated with the construction and in-use phases (the activities and results) of the area under study. However, this indicator intended to monitor the natural environmental aspects associated with the **in-use phases** of the plan area. Therefore, environmental monitoring of construction phases is not within the present scopes of indicator 12.

The study proposed that the factor relevant with the environmental monitoring of the **construction phase** of the intervention area has the potential to be added to the existing verification checklist of indicator 12. The added factor is number 5 and 6, shown in Table 36. The environmental monitoring of the construction phase is management practices of the construction sites. In fact, pollution is an issue that the construction industry cannot ignore. The pollution created by the construction activities can affect the soils, air, water, and causing noise. They can directly affect site employees and people living nearby and causing irreversible damage to habitat and wetlands or water bodies.

Therefore, the study proposed environmental monitoring of the in-use phase of the site, in which the project teams are required to create and implement an Erosion and Sedimentation Control (ESC) Plan for all construction activities associated with the project (LEED v4, 2018). The ESC Plan must conform to the erosion and sedimentation requirements of the Environmental Protection Agency (EPA) Construction General Permit (CGP) or local (equivalent) erosion and sedimentation control standards and codes, whichever is more stringent. The Plan shall describe the measures implemented to accomplish the following objectives:

- Prevent loss of soil during construction by stormwater runoff and/or wind erosion, including protecting topsoil by stockpiling for reuse.
- Prevent sedimentation of storm sewer or receiving streams.
- Prevent polluting the air with dust and particulate matter.

The Construction General Permit (CGP) outlines the provisions necessary to comply with Phase I and Phase II of the National Pollutant Discharge Elimination System (NPDES) program. While the CGP only applies to construction sites greater than 1 acre, the requirements are applied to all projects for the purposes of this prerequisite. Based on these, the necessary elements for the evaluation are:
1. General plan of the urban area or urban planning project,
2. EPA Construction General Permit (CGP) or equivalent local standards and codes.
3. Environmental Impact Studies developed for the project's intervention area, including the Erosion and Sedimentation Control (ESC) Plan. In order to calculate this factor, the measures must be evaluated within the limits of the project's intervention area, by consulting the respective regulation.
The assessment method is:

Description	Unit	Data source
Calculating the risks, through a checklist with the attribution of points.	-	Erosion and Sedimentation Control (ESC) Plan

As this indicator is already within the scope of indicator 12 of SBTool^{PT}-Urban, the new factor is proposed to be added to the existing check list of the indicator shown is Table 36, and the point number 5 and 6 are the proposed factors by the study, which are added to the list.

Table 36. Adapting the New Factor to the existing verification check list for indicator 12 – Environmental Monitoring

Verification check list for indicator 12 – Environmental Monitoring		Points
1	Existence of an environmental monitoring plan for the **in-use phase**.	**mandatory**
2	Environmental monitoring plan for the occupation phase, with duration recommended for:	
2.1	1 - 3 years;	
2.2	4-6 years;	
2.3	7-10 years.	
3	Areas covered by the Environmental Monitoring Plan:	
3.1	Water resources;	
3.2	Fauna;	
3.3	Flora;	
3.4	Noise;	
3.5	Outdoor air quality.	

Table 36 (continued).

Verification check list for indicator 12 – Environmental Monitoring		Points
4 4.1 4.2	Mandatory disclosure of results. The information is distributed to all inhabitants (by digital or physical means) and is available online; The information is available online.	
5	Existence of an environmental monitoring plan for the **construction phase**.	**mandatory**
6 6.1 6.2 6.3 6.4 6.5 6.7 6.8 6.9 6.10 6.11 6.12 6.13 6.14	Areas covered by the Environmental Monitoring Plan: preserve vegetation and mark clearing limits, establish and delineate construction access, control flow rates, install sediment controls, stabilize soils, prevent soil loss during construction, stockpile topsoil for reuse, protect slopes, protect drain inlets, all rainwater conveyance systems, and receiving water bodies, stabilize channels and outlets, control pollutants including dust and particulate matter, control dewatering, maintain the BMPs, manage the erosion and sedimentation control plan.	

4.4.3 Analysing the Issue of District Heating and Cooling, as a New Potential Factor

District Heating and Cooling - To encourage the development of energy-efficient neighbourhoods by employing district heating and cooling strategies that reduce energy use and energy-related environmental harms.

The indicator 15 of SBTool^{PT}-Urban for Centralized Energy Management focuses on controlling the use of energy for the timely identification of problems in the network and systems and increasing the potential of flexible loads in demand response. 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]. Besides this, District Energy System's impact on energy and the environment. District Energy Systems are a network of underground pipes to pump steam, hot water, and/or chilled water to multiple buildings in an area, that are used to efficiently heat and cool buildings using less energy than if the individual buildings were to each have their own boilers and chillers. Also, the use of thermal energy storage (TES) can offer significant economic, energy, and environmental advantages (Guillén-Lambea et al., 2021). District energy enables the efficient use of local resources, including e.g., waste incineration, geothermal, solar thermal, biomass/gas, excess heat from industrial processes and power generation or a combination of these, and helps communities reduce their operating costs (EESI, 2011).

District cooling and heating for buildings can be modelled for each building. The Baseline energy model must model on-site cooling, heating, and distribution equipment, and shall specify the efficiencies of the equipment (USGBC, 2014). If incorporated a district heating and/or cooling system for space conditioning and/or water heating of new buildings (at least two buildings total) such that at least 80% of the project's annual heating and/or cooling consumption is provided by the district plant (Single-family residential buildings and existing buildings of any type may be excluded from the calculation).

Based on the indicator 15 of SBTool^{PT}-Urban, Centralised Energy Management, it is intended to monitor the implementation of a centralized energy use management system (smart grid) in the public spaces of the intervention area. Calculating of the indicator is by using the following checklist, Table 37, to assess the characteristics of the centralized management system power. Therefore, the study proposed to incorporate the factor relevant with assessment of “District Heating and Cooling Systems” of the intervention area to the verification checklist of indicator 15. The added factor to the existing verification list is added as number 8. For the calculation of this indicator, the measures described must be evaluated in public outdoor spaces, in consultation with the respective specifications. Specifications of the systems to be considered, are:

1. Each system component that is addressed by ANSI/ASHRAE/IESNA Standard 90.1–2010 must have an overall efficiency performance of at least 10% better than that specified by the standard’s prescriptive requirements.
2. Annual district pumping energy consumption that exceeds 2.5% of the annual thermal energy output of the heating and cooling plant must be offset by increases in the component’s efficiency beyond the 10% improvement.

In case of a combined heat and power (CHP) system is used, it should be demonstrated that energy consumption savings from the CHP plant are at least equal to the energy savings that would result from using a conventional district energy system with components that are 10% better than ANSI/ASHRAE/IESNA Standard 90.1–2010.

Table 37. Adapting the New Factor to the Existing Verification check list for indicator 15 - Centralised Energy Management

Verification check list for indicator 15 – Centralized Energy Management		**Points**
1 1.1 1.2 1.3	Implementation of a centralized energy use management system in public buildings and public spaces (smart grid system): Measurement of the use of electricity from the grid; Measurement of the transformation and use of local Renewable Energy; Existence of smart meters.	
2 2.1 2.2 2.3	Implementation of a centralized system for managing the energy use of homes: Measurement of the use of electricity from the grid; Measurement of the transformation and use of local Renewable Energy; Existence of smart meters.	
3 3.1 3.2	Public disclosure of results: Monthly; Quarterly; Yearly.	
4 4.1 4.2	Disaggregation of information produced: Disaggregation between thermal and electric energy; Breakdown by types of use;	
5	Existence of energy management objectives / targets.	
6 6.1 6.2	Means of dissemination: The information is distributed to all inhabitants and is available online; The information is available online.	
7	Existence of energy storage systems.	
8 8.1	Incorporating a district heating and/or cooling system for space conditioning and/or water heating of new buildings (at least two buildings total) : Measurement of the project’s annual heating and/or cooling consumption is provided by the district plant (at least 80%), (Single-family residential buildings and existing buildings of any type may be excluded from the calculation).	

4.4.4 Analysing the Issue of GHG Emissions of Energy Embodied in Construction Materials, as a Potential New Factor

GHG emissions from energy embodied in construction materials - To measures the embodied non-renewable primary energy of materials used for the building construction.

This is a commonly specified environmental impact assessment factor, used in Life Cycle Assessment. This indicator promotes the use of construction materials with a low embodied energy. The embodied energy is the energy consumed by all the processes associated with the production of construction materials, from the raw materials supply to manufacturing (cradle-to-gate) energy used for the acquisition of raw materials, processing, manufacturing, and assembling building construction materials at the factory gate.

To calculate the value of the indicator it is necessary to compile a Bill of Materials (BoM) that is a mass-based inventory of the different materials (kg) that compose a building. The BoM is organised according to main elements that a building is composed of. The starting point is the Bill of Quantities (BoQ) that specifies the elements of a building (e.g., foundations, columns). The BoQ comprises different categories of elements, which can have different functional performance characteristics. BoM differs from a BoQ in that it describes the different materials (e.g., concrete, steel, aluminium) that are contained in the various building elements. Once the BoM has been compiled, it is possible to calculate the value of the indicator. BoM differs from a BoQ in that it describes the different materials (e.g., concrete, steel, aluminium) that are contained in the various building elements. Once the BoM has been compiled, it is possible to calculate the value of the indicator. The following steps should be followed to compile the Bill of Quantities (BoQ):

1. Compile the Bill of Quantities: A BoQ is compiled which comprises the building elements accounting for at least 99% of the mass of the building.
2. Identify the basic composition of each building element. A breakdown of its constituent materials has to be carried out. The mass of each constituent material has to be estimated.
3. Aggregation by material: The mass for each constituent material should thereafter be aggregated to obtain the total mass for each type of material.
4. Once the BoM has been compiled, it is possible to calculate the indicator associating to each constituent material the relative embodied primary non-renewable energy by multiplying the specific mass (i.e., kg) with its corresponding embodied energy coefficient (i.e., MJ/kg).
5. The total value of embodied primary non-renewable energy is finally normalized by the gross area of the building.

The assessment method for GHG emissions from energy embodied in construction materials can be done through MIB system, which make is easier. The method is overall described as follow:

Description	Unit	Project stage	Data source
Embodied primary non-renewable energy	MJ/m2	Design	Estimation
		Occupation	Not applicable

The necessary elements for the evaluation are:
1. The gross area of the buildings (or outdoor spaces).
2. The criterion is only applicable at the design stage.

3. In case of new construction, the indicator must be calculated taking into account all the materials used for the building (or outdoor spaces) construction.
4. In case of an existing building (or outdoor spaces), the indicator must be calculated considering only the materials used for its renovation and not the ones pre-existent.
5. The main reference standards for the indicator include ISO 14040/44, EN 15804 (Sustainability of construction works, Environmental product declarations, Core rules for the product category of construction products), and EN 15978 (Sustainability of construction works, Assessment of environmental performance of buildings, Calculation method).

Based on the indicator 19 of SBTool^{PT}-Urban, regarding the "low impact materials", which intended to calculate the Percentage of Sustainable Materials used in public spaces of the intervention area, the Sustainable Materials that are mentioned to be used in public spaces, are defined as shown in Table 38. The factor for calculating "GHG emissions of energy embodied in construction materials" is proposed to be added to the list, as shown below.

Table 38. Adapting the New Factor to the Existing list for indicator 19 – Low impact materials

Verification check list for indicator 19 – Low impact materials		**Points**
1 1.1 1.2 1.3 1.4 1.5	Percentage of Sustainable Materials area in public spaces: Certified wood fast-renewing materials Recycled materials Reused materials Local or locally produced materials	
2 2.1 2.1.1 2.2 2.2.1	Have GHG emissions from energy embodied in construction materials been assessed through the project's design stage for the intervention area?: Not: If there is no assessed. Yes: If there is assessed.	

4.4.5 Analysing the issue of Adapting to climate change, as a new potential factor

Adapting to climate change - To ensure the development is resilient to the known and predicted impacts of climate change.

The indicator 27 of SBTool^{PT}-Urban referring to Natural and technological risks, the tool promoted some measures to be taken in the development of urban projects to reduce and minimize the risks. The tool is mentioned that to comply with the issues referring to natural and technological risks, some measures to be taken in the development of urban projects, are including:

1. Preparation of the study of natural and technological risks, indicating strategies to reduce and minimize these risks:
   - Location outside flooded beds;
   - Adequate distribution of fire hydrants;
   - Regulations for the construction of buildings;
2. Development of evacuation plans and distribution of information to the population.

However, it is defined that measures to be implemented must be articulated with Environmental Impact Studies, which identify the natural and technological risks foreseen for the place, and eventual prevention measures. And, for the calculation of this indicator, the measures described above must be evaluated within the limits of the project's intervention area. The study proposed other assessments, regarding the impacts of the climate changes, to adapt by the tool, for assessment or taking measures in the project areas, including:

- increased temperatures (including the heat island effect)
- increased weather volatility
- impacts on water resources
- Changes in ground conditions.
- Snow builds up and ice.

These measures deliver benefits in addition to climate change adaptability. This can include:
1. Reducing more than one impact of climate change, for example helping to reduce the heat island effect whilst also reducing flood risk.
2. Reducing the contribution of the development site to climate change.
3. Providing additional sustainability, economic or wellbeing benefits. For example, using drainage techniques that may also increase biodiversity or improve water quality.

Specifications of the masterplans should be analysed to demonstrate how the risks will be managed and reduced through the use of win-win measures. Assessment method is to determine the degree to which the masterplan takes account of evidence of the impacts of climate change asset, through a checklist with the attribution of points.

This issue relates to the criteria in C07, I23 – Outdoor Thermal Comfort, C08, I27 – Natural and Technological Risks, C05, I16 & I17 – Efficient Drinking Water Consumption & Effluent Management, and C03, I09 & I11 – Distribution of Green Spaces & Percentage of native vegetation. Therefore, this indicator also, can be ignored from the final list.

4.4.6 Analysing the Issue of Usability of Public Transport for Physically Disabled Persons, as a New Potential Factor

Usability of Public Transport for Physically Disabled Persons - To facilitate the access to public transport by physically disabled persons.

Since accessibility is crucial to enable an autonomous life and the use of generally available goods and services, legislation, and a number of measures to ensure that persons with disabilities or sensory difficulties enjoy the autonomy, equal opportunities, and social participation to which they are entitled (UN human rights, 2012). It integrates a set of measures which aim at building a coherent overall system and unifying accessibility in order to provide persons with mobility impairments or sensory difficulties those conditions which enable them to have an autonomous life and ensure their mobility on an equal base with others, eliminating the risks of exclusion and discrimination. Accessibilities cover a wide range of issues from support products to access to buildings and transports. For the case of this indicator, the main purpose is the issue of access conditions for the transport of disabled persons and persons with reduced mobility.

Many European countries launched national disability strategy, setting out the actions the government must do to improve the everyday lives of all disabled people and included a range of solutions for succeeding the improved accessibility of public transport users with disabilities or reduced mobility. Although, most urban areas are serviced by a public transportation service, but the quality of service to be used by disabled people should be evaluated. These should include the solutions to ensure they can travel easily and more confidently, especially included an accessibility audit of the bus stations and the buses. The assessment method for assessing the Usability of Public Transport for Physically Disabled Persons, is described as follow.

Description	Unit	Data source
Evaluate the ease of access to and use of public transport for physically disabled persons, taking into account the urban area and the characteristics of public transport.	%	
Calculate the Public Transport Quality, through a checklist with the attribution of points.	-	

For the calculation of this indicator, the measures described above must be evaluated within the limits of the project's intervention area. And, the necessary elements for the evaluation are:

1. General plan of the urban area or urban planning project;
2. Regulation of the local urbanization plan;
3. Location and framing plan to the scale of the Municipal Master Plan or when it does not exist, the equivalent scale, duly marking the limits of the intervention area;
4. Map of planned or existing public transport networks that cover the area under study and respective schedules.

Based on the indicator 31 of SBTool^{PT}-Urban, regarding the "Public Transport", whose objective is to promote good conditions for mobility through an adequate public transport network, to increase the quality of transport and the local and inter modal connections. The intended public transport qualities of the indicator are defined as shown in Table 39. The proposed new factor to added to the checklist is defined as numbed 5 in the list, as shown below.

Table 39. Adapting the New Factor to the Existing list for indicator 31 – Public Transport: I. Public Transport Accessibility Index

Verification check list for indicator 31 – Public Transport		Points
1	Types of Public Transport in the Urban Area (quantity):	
1.1	type of transport	
1.2	types of transport	
1.3	or more types of transport	
2	Number of stops in the urban area (for all services)	
2.1	1 stop per km	
2.2	2 stops per km	
2.3	3 stops per km	
2.4	4 or more stops per km	
3	Average frequency of daily passage (weighted average for the busiest stops by type of service).	
3.1	Less than 10 minutes	
3.2	Between 10 minutes and 30 minutes	
3.3	Greater than 30 minutes	
4	Average number of services at rush hour (weighted average for the busiest stops by type of service)	
4.2	Less than 10 per hour	
4.3	Between 10 and 30 per hour	
4.4	Between 30 and 50 per hour	
4.5	More than 50 per hour	
5	Average number of stops and services that are usable by for physically disabled persons to travel easily and more confidently, included:	
5.1	accessibility of the bus stations	

4.4.7 Analysing the Issue of Car Parking Spaces, as a New Potential Factor

Car Parking Spaces - To facilitate the access to public facilities with the associated minimized environmental harms.

The necessity of accessibility to other types of parking are not mentioned in EU Directives, but as vehicles are present so is the practice of searching for a good parking space. However, there are many issues regarding the environmentally harmful effects of parking spaces. Marcus, J. (2014) explained that parking is always the single biggest land use in any urban environment. It takes a significant amount of energy to build this space, including the creation and transportation of concrete and precast elements. Parking spaces also trap heat, creating an urban heat island that, in turn, raises the temperature of cities. This results in an additional energy load on buildings to maintain comfortable indoor temperatures. Parking garages can also be as environmentally harmful as the cars housed in them. Meanwhile, paved surface lots are in many ways worse for the environment than garages. More paved area means fewer green areas, fewer carbon-absorbing trees and less soil absorption to replenish aquifers. These issues underpin the goal of improving the design of parking facilities.

Therefore, If vehicles must be parked, the industry can adopt sustainable principles to do so. Parking garages will never be as environmentally friendly as bicycles or rail, but they can serve as great places for rail stops or bicycle storage areas. Universal goals for sustainable parking aim to:

- help reduce the world’s dependence on fossil fuel;
- reduce the amount of land required to store vehicles;
- encourage the purchase and use of alternative-fuel vehicles and electric vehicles;
- encourage change-of-mode commutes;
- encourage carpooling;
- reduce the energy needed to operate a parking facility;
- use best sustainable practices in choosing technologies and materials;
- reclaim water from parking structures and surface lots; and
- incorporate renewable energy sources into designs.

Based on the indicator 31 of SBTool^{PT}-Urban, regarding “Public Transport” whose objective is to promote good conditions for mobility through an adequate public transport network, to increase the quality of transport and the local and inter modal connections. The intended public transport qualities of the indicator are defined as shown in Table 40. The proposed new factor to added to the checklist is defined as numbed 4 in the list. For the calculation of this indicator, the measures described must be evaluated in public outdoor spaces, in consultation with the respective specifications. Specifications of the systems to be considered, are:

- Stand-alone parking structures cannot obtain points,
- Mixed use parking structures can obtain points.
- For new non-residential buildings and multiunit residential buildings, either do not build new off-street parking lots, or locate all new off-street surface parking lots at the side or rear,

leaving building frontages facing the circulation network free of surface parking lots (alleys may be exempted).

- Use no more than 20% of the total development footprint area for all new off-street surface parking facilities, with no individual surface parking lot larger than 2 acres (0.8 hectare). For the purposes of this credit, surface parking facilities include ground-level garages unless they are under habitable building space. Underground or multistory parking facilities can be used to provide additional spaces. On-street parking spaces are exempt from this limitation.
- Provide preferred parking for carpool or shared-use vehicle parking spaces equivalent to at least 10% of the total off-street parking spaces for each nonresidential and mixed-use building on the site. Such parking spaces must be marked and within 200 feet (60 meters) walking distance of entrances to the building served.

Therefore, to comply with the issues referring to green parking, some measures to be taken in the development of new urban projects, or assessment of the existing neighbourhoods are mentioned in Table.

Table 40. Adapting the New Factor to the Existing list for indicator 31 – Public Transport: II. Public Transport Quality Index

Verification check list for indicator 31 – Public Transport		Points
1 1.1 1.2 1.3	Types of public transport offer: Minibus Line Bus network Electric or Metropolitan surface (medium / low speed) Metropolitan (medium / high speed) Bicycle sharing systems	
2 2.1 2.2	Selection of greener public transport systems: Public transport networks using clean energy Exclusive public transport routes	
3 3.1 3.2 3.3	Conditions of available public transport stops (select an option): Covered waiting facilities Covered waiting facilities with benches Covered waiting facilities, providing benches and adequate lighting Covered waiting facilities, providing benches and adequate lighting, and real-time information	
4 4.1 4.2 4.2.1 4.2.2 4.2.3 4.2.4 4.2.5 4.2.6 4.3	Creation or existence of car parks spaces: Car parks on the outskirts with access to public transport. Car parks on the site with access to public transport: Shared parking Green Roofs over underground parking Green Roofs atop above ground parking Solar panels atop parking, provide some or all the energy needs Solar panels atop canopies Parking “Meter pops” Using no more than 20% of the total development footprint area for all new off-street surface parking facilities, with no individual surface parking lot larger than 2 acres.	

Shared parking is defined as parking space that can be used to serve two or more individual land uses, without conflict or encroachment. As Burns (2016) explained, the opportunity to implement shared parking is the result of two conditions: variations in the peak accumulation of parked vehicles as a result of different activity patterns of adjacent or nearby land uses (by hour, by day, by season), and relationships among land use activities that result in people’s attraction to two or more land uses on a single auto trip to a given area or development. Shared parking is a way to optimise the parking spaces cities (Mobypark). Private parking owners such as hotels, companies, universities, hospitals, etc. and individuals can rent out their parking space at times they don't use it. This allows drivers to park their car at parking spaces that are so far not accessible for them. It also allows us, to offer these parking spaces at better prices, compared to regular parking tariffs. Hence every parking owner can rent out their parking space via the relevant websites.

5. DISCUSSION

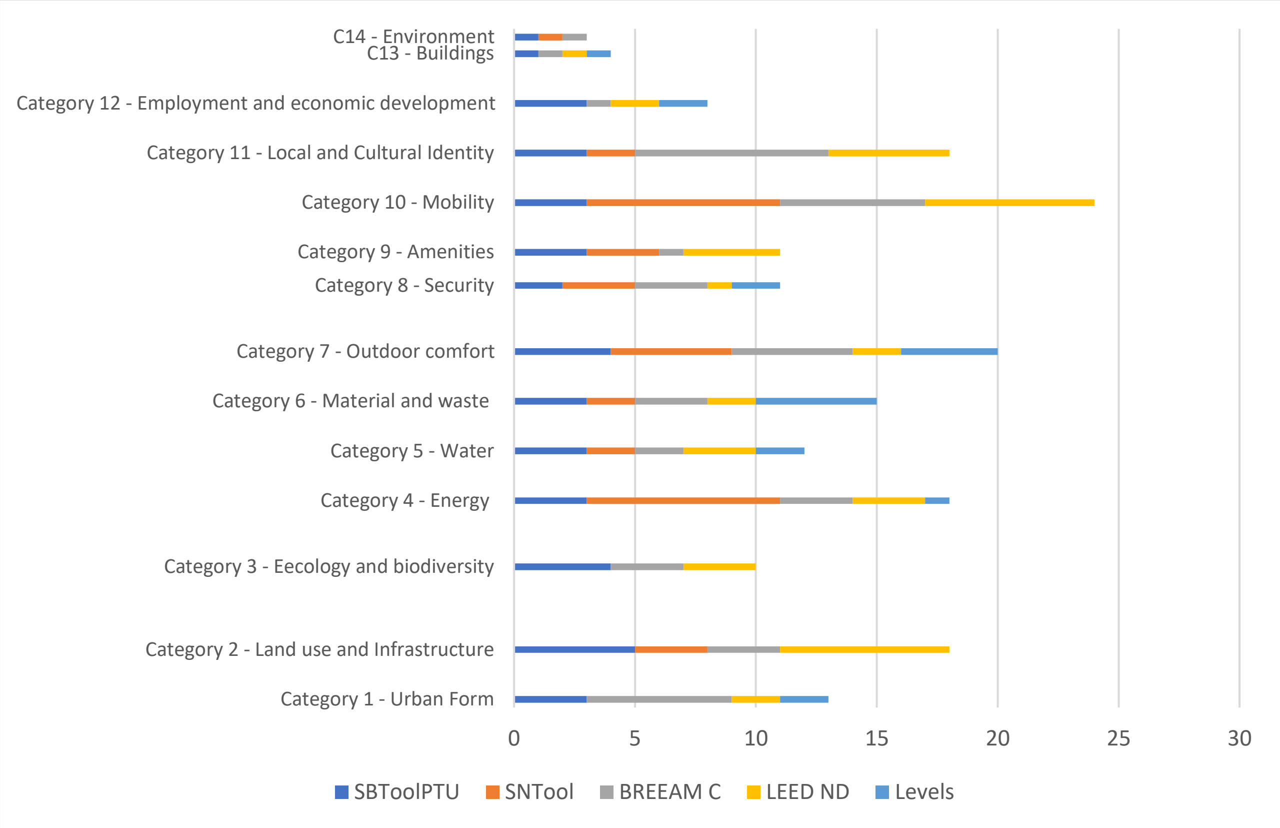
Currently, sustainable community rating tools are primarily developed on a global scale. This research reviews and compares three sustainable community rating tools in terms of their issues, aspects, and contents and compare them with the same issues in SBTool^{PT}-Urban. The results provided iiSBE Portugal with potential new indicators and factors to be adapted by the tool. Moreover, the study identifies the compatibility of the strategies conducted by the tool with the developed global scale strategies for sustainability of urban areas.

5.1 Comparison of the indicators of SBTool^{PT}-Urban method and other existing methods

The evaluation of the tool began with the comparison analysis of the indicators of the chosen tools. Each category has one or more indicators, which are variables for quantitative or qualitative measurements. Indicators are important for target setting and monitoring (Häkkinen & Espoo, 2007), and are useful tools to communicate ideas, thoughts, and values (Verbruggen & Kuik, 1991). Indicator comparison is the most detailed comparison and is conducted in 33% of the selected papers (Li et al., 2017). Since there are many variables used in each method, it is also unlikely to compare the entire variables. Instead, comparison in this study focused on aspects and issues, based on the present 14 categories of SBTool^{PT}-Urban. The categories are including Urban Form, Land use and Infrastructure, Ecology and biodiversity, Energy, Water, Material and waste, Outdoor comfort, Security, Amenities, Mobility, Local and Cultural Identity, Employment and economic development, Buildings, and Environment.

The evaluated rating tools all aiming to assess the sustainability of urban development projects, and the results show that they focus on similar aspects of sustainability measurement. However, the emphasise of each tool on different issues and aspects, and their assessment approach are varied. For instance, based on the categories SNTool emphasizes more on energy, mobility, outdoor comfort, amenities, and security (adaption to climate changes). BREEAM-C has a greater number of indicators relevant to local and cultural identity, urban form and mobility, and LEED-ND prioritized on land use and infrastructure, mobility, and local and cultural identity. In overall, the categories which are assigned the majority of the relevant indicators, as shown in Figure 18, are including: Mobility, Outdoor Comfort, Land use and Infrastructures, Local and Cultural Identity, and Energy. However, the system of points and the mandatory or prerequisite indicators which considered for each indicator are different in each tool. Also, unlike BREEAM-C and LEED-ND, which has a system of points to be gained through complying with their lists of measurements, known as qualitative approach, the indicators of SNTool have a quantitative approach and are based on statistical calculations. However, SBTool^{PT}-Urban has a mix approach including qualitative and quantitative indicators, but the majority of the indicators are developed based on qualitative approaches, based on attribution of points.

Figure 15. The frequency of the categories, based on the categories of SBTool^{PT}-Urban.



Concerning the identification of the potential new issue and aspects to be adapted to the tool, the comparison of the sustainable community rating tools reveals that:

- SBTool^{PT}-Urban include the majority aspects related to land use and infrastructure, but an important sustainability aspect, including **Conservation of Land** is neglected. This aspect has the potential to be considered as a new indicator, to be added to this category.
- Then, the analysis reveals that the majority aspects related to the category of ecological and biodiversity are defined. However, the aspect relevant with the **Construction Activity Pollution Prevention** is a factor, which has the potential to be attached to the verification list of the indicator 12, regarding Environmental monitoring.
- Next, the study indicates that SBTool^{PT}-Urban made up of the majority aspects related to energy issue, but the sustainability aspect, **District Heating and Cooling** is abandoned. This factor has the potential to be included in the indicator 15, regarding Centralised Energy Management.
- Following, the study disclosed that SBTool^{PT}-Urban include the main aspects related to Material and waste, but an important sustainability factor, regarding the assessment of **GHG emissions from energy embodied in construction materials** is overlooked. This factor has the potential to be adopted to the verification list of the indicator 19, regarding Low Impact Materials.
- Then, for the category of security, the analysis revealed that the majority aspects are considered. But, the aspects relevant with **adaption to climate change** have the potential to be improved. In this regard, the indicator 27 for Natural and technological risks can be updated

to encompass more factors, adapting the relevant risk assessment impacts of the climate changes.

- The last one is analysing the category of mobility, revealing that the majority aspects related to this category are defined. But, two factors relevant with the **Usability of Public Transport for Physically Disabled Persons, and Car Parking Spaces** are the factors, which has the potential to be attached to the verification list of the indicator 31, regarding Public Transport. However, the two identified new indicators were not recommended by EU Directives, but as vehicles are present so it is proposed to practice of developing green parking spaces, which can help sustainability in the cities.

In overall, the comparison analysis of the assessment tools identified that, the strategies developed by the sustainability assessment method of SBTool^{PT}-Urban is highly compatible with the well-known sustainability assessment methods in terms of the issues and aspects that comprised. Although, they are taken varying calculation approach, scoring, and different categorisation and/ or classification of the issues, but they are highly relying on an identical list of issues for sustainability indicators, which are compatible with Sustainable Development Goals for 2030. Based these, the proposed changes are aligned with the six purposes of sustainability, based on ISO 37101, including: Attractiveness, Preservation and improvement of environment, Resilience, Responsible resource use, social cohesion, and Well-being. And, the proposed indicators by the study strive to improve:

1. Conserving natural capital, through the proposed indicator for Conservation of land.
   - Improving the consideration of water resources and biodiversity conservation.
2. Raising sustainability awareness, and their relevant action in construction sites, through the proposed factor of Construction activity pollution prevention
   - Educating and enlightening of the employers and employees so that they understand the importance of environmental issues and adapt measures that are environmentally friendly.
3. Accelerating of the sustainable energy for All, through encouraging District heating and cooling
   - Supporting market transformation efforts to shift the heating and cooling sector to energy efficient and renewable energy solutions.
4. Realizing a low-carbon society, through proposing the assessment of GHG emissions from energy embodied in construction materials.
   - Promoting environmental load reduction targets.
5. Fulfilling legal compliance and international responsibilities, by Adapting to climate change,
   - Responding to natural disasters associated with climate change, collaborating with the society through cooperation with local municipalities and disaster prevention and mitigation services, etc., and stimulating the domestic laws and regulations related to environmental conservation.
   - Supporting international environmental initiatives and collaborating with the international community to combat climate change.
6. Cooperating with the society through improved services, through encouraging Usability of public transport for physically disabled people.
   - Eliminating the risks of exclusion and discrimination, to ensure a sustainable society.
7. Converting threats to opportunities, through promoting Sustainable car parking spaces
   - Minimizing the environmental harms associated with parking facilities, and even adopting them for sustainability purposes.

6. CONCLUSION

This research analysed the present framework of indicators of SBTool^{PT}-Urban, through comparison with the indicator's framework of a series of selected sustainability assessment methods including BREEAM-C, LEED-ND, and SNTool (minimum version). The study reorganized the most relevant urban sustainability indicators based on 14 categories of SBTool^{PT}-Urban. Indicators in the analysed methods that have different titles but address similar issues and aspects are considered the same and organized under the same category (Table 6). Moreover, the charts provided for each category (Figures 1–14) illustrate the level of frequency of each indicator among the studied methods. Additionally, this determines whether they are addressed by Level(s), ISO 37120 standards for sustainable communities and the SDGs of Agenda 2030. Moreover, as legal instruments are, undoubtedly, very important for defining and establishing a sustainable environment, therefore the study analysed the compatibility of the proposed new potential indicators to be aligned with EU Directives.

Conservation of lands with ecological values, relevant with preserving of natural resources, identified as an underestimated environmental issue by SBTool^{PT}_Urban. Despite the generalised effort to evaluate the native vegetation of a site by the tool, the effort on solving and mitigating the problem of development on the lands with ecological values, mostly in sensitive areas, is neglected. However, this indicator is promoted by SNTool, BREEAM-C, and LEED-ND, and is addressed by ISO, and SDGs. This indicator is recommended by EU Directives, as well. Also, the habitat characteristics linked to biodiversity and ecosystem services that are vital to the maintenance of human well-being (Quintas-Soriano et al., 2016).

The potential of urban morphology (i.e., the design of roads along with land use, densities, urban forms, enhancement of natural potential of the sites, etc.) on the thermal performance of the spaces, and health and comfort of inhabitants are the factors, which predominantly were highlighted SBTool^{PT}_Urban than its similar kinds in the other tools.

The potential effects of urban morphology (i.e., the design of roads along with land use, densities, urban forms, enhancement of natural potential of the sites, etc.) on thermal performance of the spaces, and health and comfort of inhabitants are the factors, which are considered by the tool. The relevant categories of these factors are defined firm enough, in SBTool^{PT}_Urban, as compare with its similar kinds in the other tools.

Waste and water management are environmental issues, which have been part of Portugues local governments´ agenda for many years (Barros & Cabral, 2010), therefore the importance revealed on this study for these issues does not come as a surprise. However, regarding waste management, there is a lack of concern on analysing the GHG emissions from energy embodied in construction materials, since this element is considered essential in SNTool and is part of the Level(s) principle, and ISO standards. So, this factor can be added to an indicator, which assess the application of low impact materials in a project. However, embodied carbon is more difficult to measure and track as compared with operational carbon, which is relatively simple to extrapolate from occupants' energy bills. But there are different methods that can be adapted to evaluate the embodied carbon of a wide range of building materials.

Energy is the most uniform category and promoted by all the evaluated tools and standards. The results reveals that although the indicators of the tools have dissimilarities in approach, but they follow the same goals regarding reduction of non-renewable energy consumption. Approved that energy is a fundamental resource for human development, so it is essential to include in any sustainable system proposal, measures to ensure its efficient management (Nilsson & Bergstrom, 1995), as well to promote renewable energies (Evans et al. 2009).

Adapting to climate change and air quality are the key environmental factors to sustainability. For this reason, there are various policies and EU Directives that address these issues. However, the measures proposed in the directives are mainly addressed by the various indicators in the tool, but there are still the measures that can enhance the effectiveness of the evaluation method of the tool, if being adapted, which are proposed by the study.

The concept of sustainable communities emphasize on a good network of transport infrastructure and mobility, the existence of services, a diversified economic base, in offering socio-cultural, in the provision of housing for different segments populations, a quality environment, and the existence of good connection between the local and community participation that is related to a good connection between the local and community participation that is related to a good governance model (ODPM, 2004). Accordingly, and based on the comparisons that the study developed, amenities, mobility, local and cultural identity, and employment and economic development are the categories that have broadly enough covered the relevant issues.

Regarding the methodology used, since the main objective of the study is to enhance the issues covered by the SBTool^{PT}_Urban based on the emerged new aspects of sustainability, a comparative analysis of 522 indicators of the chosen sustainability assessment methods conducted to compares the aspects of sustainability used. The total of the chosen 7 new potential indicators, and/or factors are collected. To ascertain the alignment of the new potential indicators with the global urban sustainability policies, the relevant EU policies assessed. The results reveal that 5 new potential indicators are not addressed by the EU policies and are aligned with Level(s), ISO 37120, and SDGs, and 2 new potential indicators are not obligatory by EC policies, but there is evidence that show their importance to be adapted by the tool. The system of weighting is not considered to be analysed in this study. However, a further study is needed, for:

a. Development of the benchmarks (good and standard practices) for the new indicators,
b. The adaptation of the weighing system,
c. Development of a software tool, based on the method, to enable a straightforward consultation, understanding and classification.

REFERENCES

Afkarina, K.I.I., Wardana, S., Damayanti, P., (2019). Coal mining sector contribution to environmental conditions and human development index in East Kalimantan province. *Environmental Science and Sustainable Development*, 2(2), 192-207. DOI: https://doi.org/10.7454/jessd.v2i2.1025

Balaras, C. A., Droutsa, K. G., Dascalaki, E. E., & Kotoyiannidis, S. (2018). Holistic sustainability assessment systems for buildings and neighborhoods. *Zbornik Međunarodnog kongresa o KGH*, 49(1), 239-250. DOI: https://doi.org/10.24094/kghk.018.49.1.239

Balaras, C. A., Droutsa, K. G., Dascalaki, E. G., Kontoyiannidis, S., Moro, A., & Bazzan, E. (2020). A transnational multicriteria assessment method and tool for sustainability rating of the built environment. *In IOP conference series: earth and environmental science*, 410, 1, 012068. IOP: https://iopscience.iop.org/article/10.1088/1755-1315/410/1/012068/meta

Barros, A., Cabral, H., (2010). Urban sustainability policies at a local level: the case study of Portugal. Bringing City Form Back in to Planning. CITTA 3rd Annual Conference on Planning Research, Porto (FEUP), International Conference Proceedings Book.

Berardi, U. (2013). Sustainability assessment of urban communities through rating systems. Environment, development, and sustainability, 15(6), 1573-1591. DOI: https://doi.org/10.1007/s10668-013-9462-0

BREEAM (2012). BREEAM Communities, Technical manual SD202. BRE Global ltd. Available online: https://www.breeam.com/communitiesmanual/#resources/otherformats/output/10_pdf/20_a4_pdf_screen/sd202_breeam_communities_1.2_screen.pdf

USGBC (2014). Treatment of Scandinavian district energy systems in LEED. Energy models for LEED EA credit, 1. Available in: https://www.sgbc.se/app/uploads/2020/06/Treatment-of-Scandinavian-District-Energy-Systems-in-LEED-v1.1-2014.pdf (access in 21 July 2022)

CESBA MED (2019). CESBA MED for Sustainable MED Cities, CESBA MED Guide, Version 3, D5.3.2. Available online: https://efficient-buildings.interreg-med.eu/fileadmin/user_upload/Sites/Efficient_Buildings/Projects/CESBA_MED/D5.3.2_CESBA_MED_Guide_English.pdf (accessed in 21 July 2022)

Cutore, P., Campisano, A., Kapelan, Z., Modica, C., Savic, D. (2008). Probabilistic prediction of urban water consumption using the SCEM-UA algorithm. Urban Water Journal, 5(2), 125-132. DOI: https://doi.org/10.1080/15730620701754434

Cui, P., Mao, Y., Shen, Y., Ma, J. (2021). Moral identity, and subjective well-being: The mediating role of identity commitment quality. *Environmental Research and Public Health*, 18(18), 9795. DOI: https://doi.org/10.3390/ijerph18189795

Engel-Yan, J., Kennedy, C., Saiz, S., & Pressnail, K. (2005). Toward sustainable neighbourhoods: the need to consider infrastructure interactions. Canadian Journal of Civil Engineering, 32(1), 45-57. DOI: https://doi.org/10.1139/l04-116

Evans, A., Strezov, V., Evans, T. J. (2009). Assessment of sustainability indicators for renewable energy technologies. Renewable and sustainable energy reviews, 13(5), 1082-1088. DOI: https://doi.org/10.1016/j.rser.2008.03.008

EC (2020a). EU Biodiversity Strategy for 2030. Bringing nature back into our lives. Brussels, 20.5.2020 COM(2020) 380 final. Available in: https://eur-lex.europa.eu/resource.html?uri=cellar:a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1.0001.02/DOC_1&format=PDF (accessed on 21 July 2022)

EC (2021a). Pathway to a Healthy Planet for All, EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil', SWD(2021) 140 final. Brussels, 12.5.2021 COM(2021) 400 final. Available in: https://eur-lex.europa.eu/resource.html?uri=cellar:a1c34a56-b314-11eb-8aca-01aa75ed71a1.0001.02/DOC_1&format=PDF (accessed on 21 July 2022)

EC (2021b). Proposal for a directive of the European parliament and of the council on the energy performance of buildings (recast). Brussels, 15.12.2021 COM(2021) 802 final. Available in: https://eur-lex.europa.eu/resource.html?uri=cellar:c51fe6d1-5da2-11ec-9c6c-01aa75ed71a1.0001.02/DOC_1&format=PDF (accessed on 21 July 2022)

EC (2021c). European Green Deal: Commission adopts new proposals to stop deforestation, innovate sustainable waste management and make soils healthy for people, nature and climate. Available in: https://ec.europa.eu/commission/presscorner/detail/en/ip_21_5916 (accessed on 21 July 2022)

EC (2021d). REGULATION (EU) 2021/1119 for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 (‘European Climate Law’). Available in: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R1119 (accessed on 21 July 2022)

EC (2021e). Climate-ADAPT strategy 2022-2024, Sharing knowledge for a climate-resilient Europe. Available in: https://climate-adapt.eea.europa.eu/about/climate-adapt-strategy-2022-2024-final.pdf (accessed on 21 July 2022)

EC (2021f). Forging a climate-resilient Europe -The new EU Strategy on Adaptation to Climate Change, Brussels, 24.2.2021 COM(2021) 82 final{COM(2021) 82 final. Available in: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0082&from=EN (accessed on 21 July 2022)

EC (2020a). Commission Implementing Regulation (EU) No 749/2014. Available in: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020R1208&from=EN (accessed on 21 July 2022)

EC (2018a). Directive (EU) 2018/2002 OF The European parliament and of the council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency. Available in: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2002&rid=7#:~:text=This%20Directive%20establishes%20a%20common,way%20for%20further%20energy%20efficiency (accessed on 21 July 2022)

EC (2018b). Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU, Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council. Available in: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R1999&from=EN (accessed on 21 July 2022)

EC (2011a). Roadmap to a Resource Efficient Europe. COM (2011) 571 final. Available in: https://www.europarl.europa.eu/meetdocs/2009_2014/documents/com/com_com(2011)0571_/com_com(2011)0571_en.pdf (accessed on 21 July 2022)

EC (2011b). Regulation (EU) No 181/2011 of the European parliament and of the council, concerning the rights of passengers in bus and coach transport and amending Regulation (EC) No 2006/2004. Available in: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011R0181&from=EN (accessed on 21 July 2022)

EC (2010a). DIRECTIVE 2010/31/EU - Energy performance of buildings directive. Available in: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:en:PDF (accessed on 21 July 2022)

EC (2013). Regulations, supplementing ITS Directive 2010/40/EU, the provision of information services for safe and secure parking places for trucks and commercial vehicles. Available in: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0885&from=EN (accessed on 21 July 2022)

EESI (2011). Fact sheet, what is district energy?. Environmental and energy study institute, Washington, DC. Available in: https://www.eesi.org/files/district_energy_factsheet_092311.pdf (accessed on 21 July 2022)

Guillén-Lambea, S., Carvalho, M., Delgado, M., Lazaro, A. (2021). Sustainable enhancement of district heating and cooling configurations by combining thermal energy storage and life cycle assessment. Clean Technologies and Environmental Policy, 23(3), 857-867. DOI: https://doi.org/10.1007/s10098-020-01941-9

Gavrilescu, M., & Murray, M. (2011). 2.66-Sustainability,”. Comprehensive biotechnology, 905-923.

ODPM (Great Britain. Office of the Deputy Prime Minister), (2004). The Egan review: skills for sustainable communities. Office of the Deputy Prime Minister, London, England. The urban green structures, form and function. http://hdl.voced.edu.au/10707/19415.

Hezri, A. A. (2004). Sustainability indicator system and policy processes in Malaysia: a framework for utilisation and learning. Journal of environmental Management, 73(4), 357-371.

Haapio Appu, Towards sustainable urban communities, Environ. Impact Assess. Rev. 32 (2012) 165–169, http://dx.doi.org/10.1016/j.eiar.2011.08.002. DOI: https://doi.org/10.1016/j.jenvman.2004.07.010

Hamilton, I. G., Summerfield, A. J., Lowe, R., Ruyssevelt, P., Elwell, C. A., Oreszczyn, T. (2013). Energy epidemiology: A new approach to end-use energy demand research. Building Research & Information, 41(4), 482-497. DOI: https://doi.org/10.1080/09613218.2013.798142

Häkkinen, T. (2007). Trends and Indicators for Monitoring the EU Thematic Strategy on Sustainable Development of Urban Environment: Final report. Summary and recommendations. https://publications.vtt.fi/pdf/publications/2007/P643.pdf

Kowarik, I., Fischer, L.K., Kendal, D. (2020) Biodiversity conservation and sustainable urban development. Sustainability, 12(12), 4964. DOI: https://doi.org/10.3390/su12124964

Kim, M. J., Oh, M. W., & Kim, J. T. (2013). A method for evaluating the performance of green buildings with a focus on user experience. Energy and buildings, 66, 203-210. DOI: https://doi.org/10.1016/j.enbuild.2013.07.049

Kaur, H.; Garg, P. Urban sustainability assessment tools: A review. J. Clean. Prod. 2019, 210, 146–158. DOI: https://doi.org/10.1016/j.jclepro.2018.11.009

LEED v4 (2018a). LEED for Neighborhood development. U.S. Green Building Council, 2018. Available online: https://www.usgbc.org/resources/leed-v4-neighborhood-development-current-version

LEED v4 (2018b). LEED for Neighborhood development. U.S. Green Building Council, 2018. Available online: https://www.usgbc.org/credits/core-shell/v20/ssp1

Li, Y., Chen, X., Wang, X., Xu, Y. and Chen, P.H., 2017. A review of studies on green building assessment methods by comparative analysis. Energy and Buildings, 146, pp.152-159. DOI: 10.1016/j.enbuild.2017.04.076

Lee, W. L., & Burnett, J. (2008). Benchmarking energy use assessment of HK-BEAM, BREEAM and LEED. Building and environment, 43(11), 1882-1891. DOI: https://doi.org/10.1016/j.buildenv.2007.11.007

Lockwood, C. (2006). Building the green way, Harvard Business Review. 84 (2006) 129–137. Available in: https://hbr.org/2006/06/building-the-green-way

Marcus, J. (2014). Creating a context for sustainable parking, Land use planning and facility design can mitigate the inevitability of automobiles. Available in: https://www.reminetwork.com/articles/creating-a-context-for-sustainable-parking/

Moro, A., (2019). D3.4.2 - CESBA MED KPIs and Passport, building and urban scale. CESBA MED: SUSTAINABLE CITIES, Interreg Mediterranean, iiSBE Italia R&D. Available in: https://cesba-med.interreg-med.eu/results/deliverables/detail/?tx_elibrary_pi1%5Blivrable%5D=8337&tx_elibrary_pi1%5Baction%5D=show&tx_elibrary_pi1%5Bcontroller%5D=Frontend%5CLivrable&cHash=8afbe1078a7e4816384ead41a738fce5 (accessed on 21 July 2022).

Mobypark. What is shared parking? Available in: https://www.mobypark.com/en/faq/what-is-shared-parking

Nilsson, J., Bergström, S. (1995). Indicators for the assessment of ecological and economic consequences of municipal policies for resource use. *Ecological Economics*, *14*(3), 175-184. DOI: https://doi.org/10.1016/0921-8009(95)00013-Y

Oxfam international, (2022). 5 natural disasters that beg for climate action. Available on: https://www.oxfam.org/en/5-natural-disasters-beg-climate-action

Partridge, M., Olfert, M.R., Alasia, A. (2007). Canadian cities as regional engines of growth: agglomeration and amenities. Canadian Journal of Economics/Revue canadienne d'économique, 40(1), 39-68. DOI https://doi.org/10.1111/j.1365-2966.2007.00399.x

Pires, S.M., Fidélis, T., Ramos, T.B. (2014). Measuring and comparing local sustainable development through common indicators: Constraints and achievements in practice. *Cities*, 39, 1–9. DOI: Measuring and comparing local sustainable development through common indicators: Constraints and achievements in practice

Quinn, C., Snell, C. (2017). Peter Rogers, Kazi Jalal, & John Boyd, An Introduction to Sustainable Development. Sustain. Sci. Pract. *Policy*, 4, 50–51. DOI: https://doi.org/10.1080/15487733.2008.11908015

Quintas-Soriano, C., Castro, A. J., Castro, H., García-Llorente, M. (2016). Impacts of land use change on ecosystem services and implications for human well-being in Spanish drylands. Land use policy, 54, 534-548. DOI: https://doi.org/10.1016/j.landusepol.2016.03.011

Ryfield, F., Cabana, D., Brannigan, J.; Crowe, T. (2019). Conceptualizing 'sense of place'in cultural ecosystem services: A framework for interdisciplinary research. Ecosystem Services, 1;36, 100907. DOI: https://doi.org/10.1016/j.ecoser.2019.100907

Steiniger, S., Wagemann, E., de la Barrera, F., Molinos-Senante, M., Villegas, R., de la Fuente, H., Vives, A., Arce, G., Herrera, J.C., Carrasco, J.A. and Pastén, P.A., (2020). Localizing urban sustainability indicators: The CEDEUS indicator set, and lessons from an expert-driven process. *Cities*, 101, 102683. DOI: https://doi.org/10.1016/j.cities.2020.102683

Sharifi, A., Murayama, A. (2013). A critical review of seven selected neighborhood sustainability assessment tools. Environmental impact assessment review, 38, 73-87. DOI: https://doi.org/10.1016/j.eiar.2012.06.006

Shen, L. Y., Ochoa, J. J., Shah, M. N., Zhang, X. (2011). The application of urban sustainability indicators–A comparison between various practices. Habitat international, 35(1), 17-29. DOI: https://doi.org/10.1016/j.habitatint.2010.03.006

Sharifi, A., & Murayama, A. (2013). A critical review of seven selected neighborhood sustainability assessment tools. Environmental impact assessment review, 38, 73-87. DOI: https://doi.org/10.1016/j.eiar.2012.06.006

Shamseldin, A. K. M. (2018). Including the building environmental efficiency in the environmental building rating systems. Ain Shams Engineering Journal, 9(4), 455-468. DOI: https://doi.org/10.1016/j.asej.2016.02.006

UN-HABITAT, (2010). Planning Sustainable Cities, UN-Habitat Practices and Perspective. Available on: https://unhabitat.org/planning-sustainable-cities-un-habitat-practices-and-perspectives (accessed on 21 July 2022).

UN-HABITAT, (2015). The Right to Adequate Housing, Fact Sheet No. 21/Rev.1. Office of the United Nations High Commissioner for Human Rights. ISSN 1014-5567. Available online: https://unhabitat.org/sites/default/files/download-manager-files/Right%20to%20adequate%20housing.pdf

UNEP, (2021). Global district energy climate awards. District energy in cities initiative. Available in: https://wedocs.unep.org/bitstream/handle/20.500.11822/31588/DECI.pdf?sequence=1&isAllowed=y

UN human rights, (2016). Committee on the Rights of Persons with Disabilities examines report of Portugal. Available in: https://www.ohchr.org/en/press-releases/2016/03/committee-rights-persons-disabilities-examines-report-portugal

UN human rights, (2012). Initial Report of Portugal on the implementation of the Convention on the Rights of Persons with Disabilities. Available in: https://www.inr.pt/documents/11309/44742/Relat%C3%B3rio+inicial+de+Portugal+sobre+a+implementa%C3%A7%C3%A3o+da+Conven%C3%A7%C3%A3o/6fc3af38-a5cf-49a1-a21b-c9e472d55cab

Verbruggen, H., Kuik, O. (1991). Indicators of sustainable development: an overview. In: Kuik, O., Verbruggen, H. (eds) In Search of Indicators of Sustainable Development. Environment & Management, vol 1. Springer, Dordrecht. DOI: https://doi.org/10.1007/978-94-011-3246-6_1

Wangel, J., Wallhagen, M., Malmqvist, T., & Finnveden, G. (2016). Certification systems for sustainable neighbourhoods: What do they really certify?. Environmental impact assessment review, 56, 200-213. DOI: https://doi.org/10.1016/j.eiar.2015.10.003

Zaborova, D., & Musorina, T. (2022). Environmental and Energy-Efficiency Considerations for Selecting Building Envelopes. Sustainability, 14(10), 5914. DOI: https://doi.org/10.3390/su14105914

INCLUDED PUBLICATION

Salati, M., Bragança, L., & Mateus, R. (2022). Sustainability Assessment on an Urban Scale: Context, Challenges, and Most Relevant Indicators. *Applied System Innovation*, *5*(2), 41.

DOI: https://doi.org/10.3390/asi5020041

applied system innovation

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

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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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Citation: Salati, M.; Bragança, L.; Mateus, R. Sustainability Assessment on an Urban Scale: Context, Challenges, and Most Relevant Indicators. *Appl. Syst. Innov.* **2022**, *5*, 41. https://doi.org/10.3390/asi5020041

Academic Editor: Evangelos Bellos

Received: 3 March 2022
Accepted: 1 April 2022
Published: 7 April 2022

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.

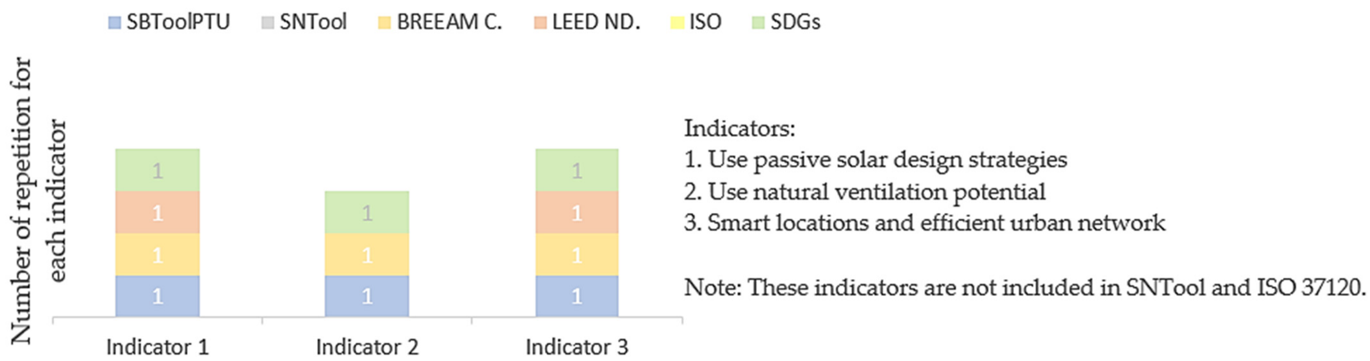

Figure 1. Frequency distribution of each indicator, relevant to the category of urban structure and form in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120 and SDGs.

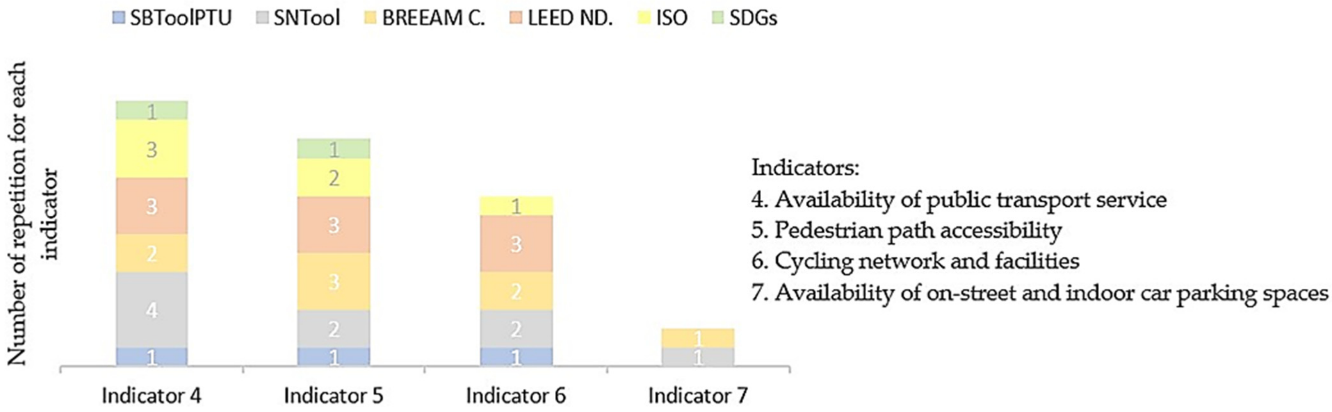

Figure 2. Frequency distribution of each indicator, relevant to the category of transportation infrastructure in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120 and SDGs.

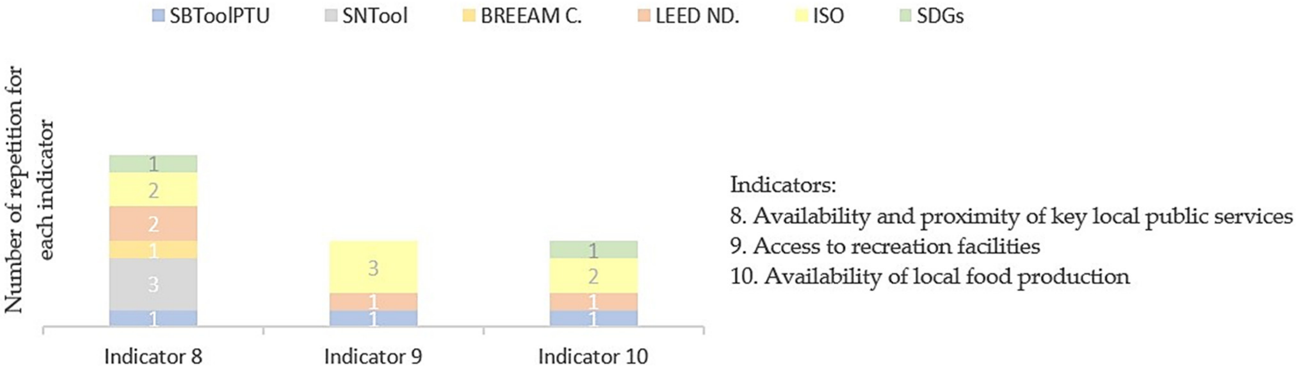

Figure 3. Frequency distribution of each indicator, relevant to the category of essential service availability in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120, and SDGs.

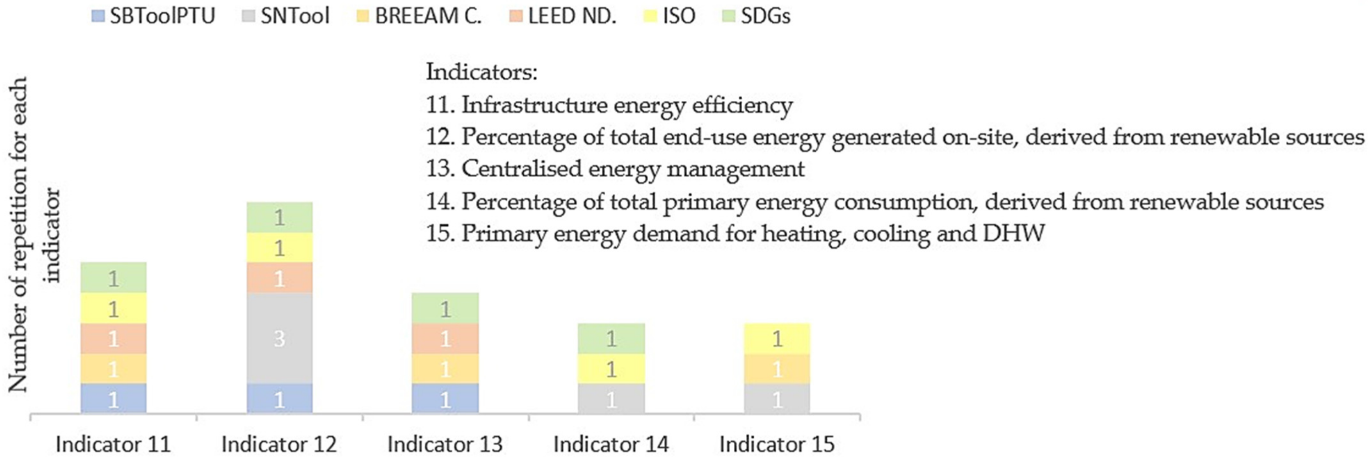

Figure 4. Frequency distribution of each indicator, relevant to the category of energy-saving measures in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120, and SDGs.

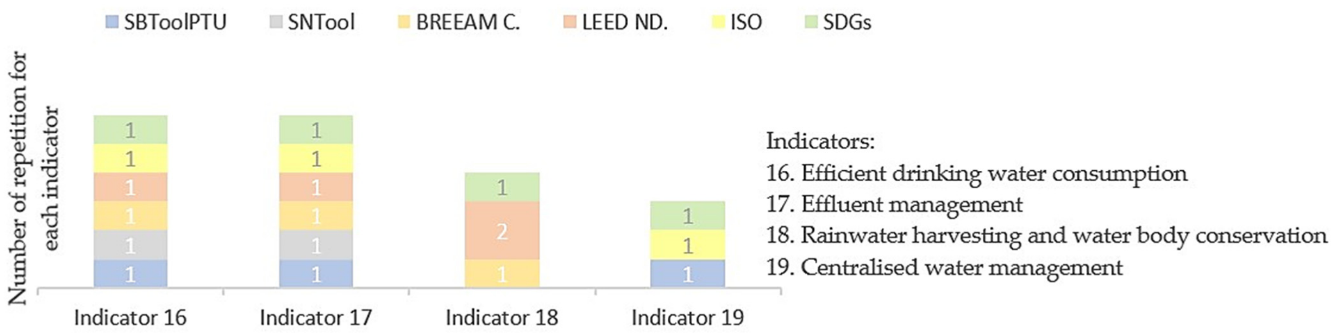

Figure 5. Frequency distribution of each indicator, relevant to the category of water-saving measures in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120, and SDGs.

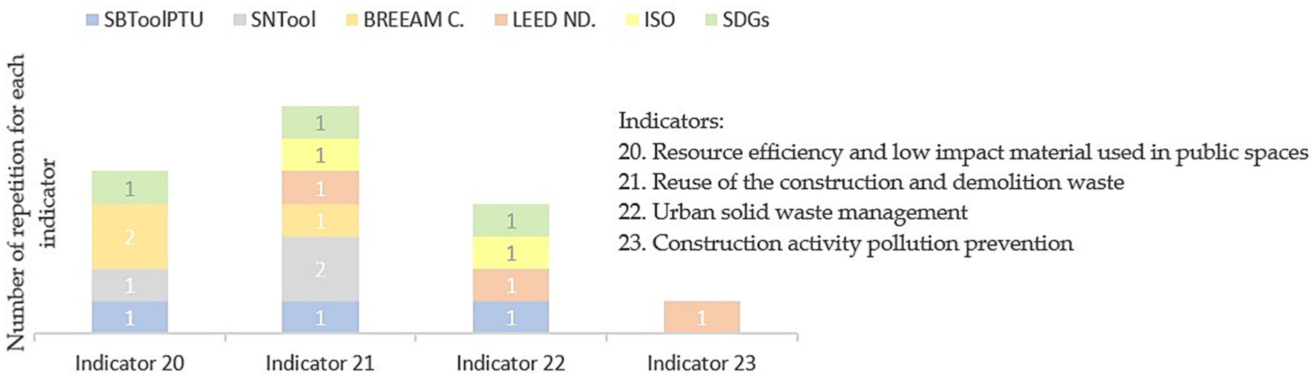

Figure 6. Frequency distribution of each indicator, relevant to the category of waste measures in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120 and SDGs.

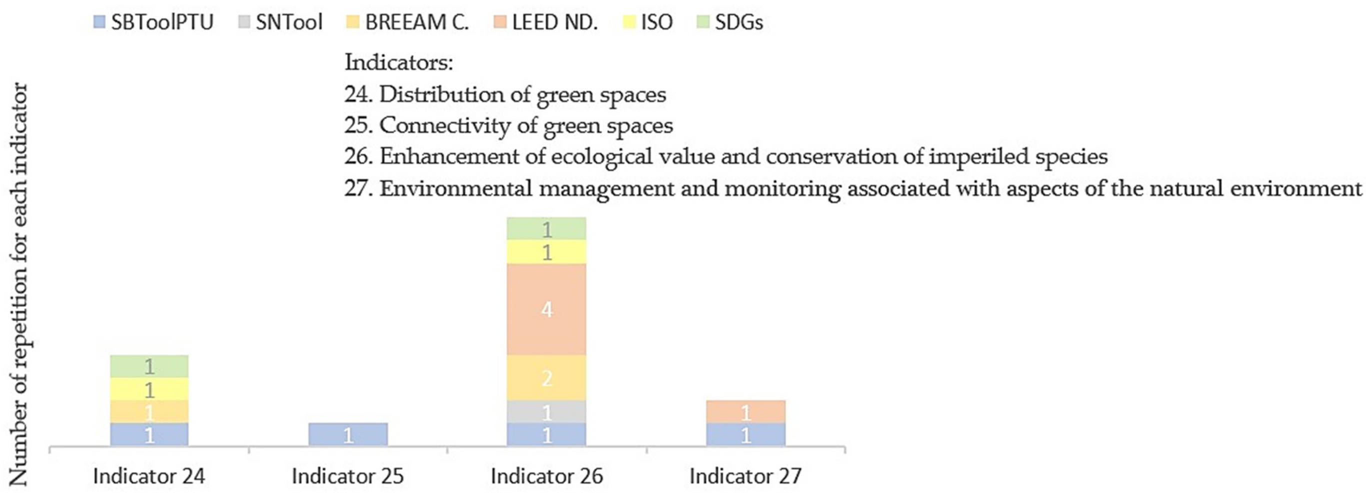

Figure 7. Frequency distribution of each indicator, relevant to the category of ecosystems and landscapes in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120, and SDGs.

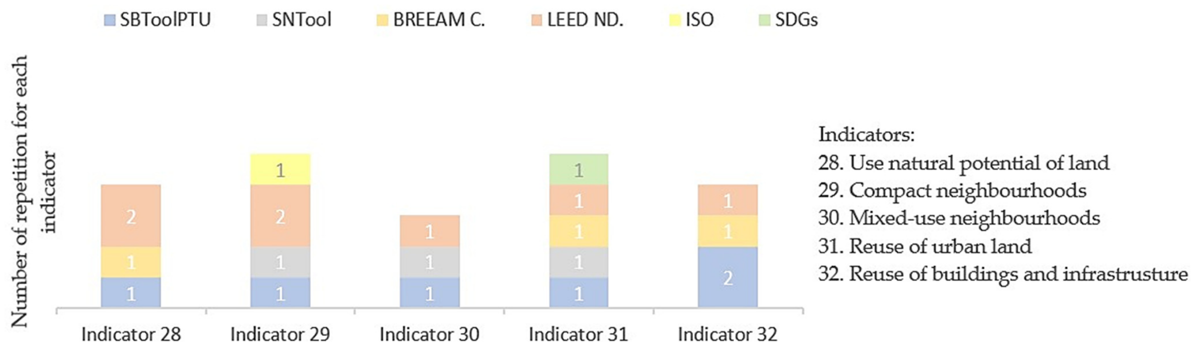

Figure 8. Frequency distribution of each indicator, relevant to the category of land use and infrastructure in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120, and SDGs.

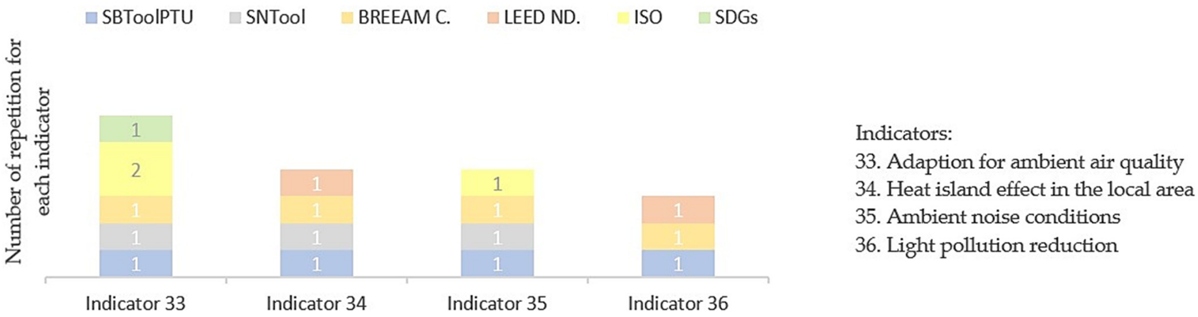

Figure 9. Frequency distribution of each indicator, relevant to the category of outdoor environmental quality in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120 and SDGs.

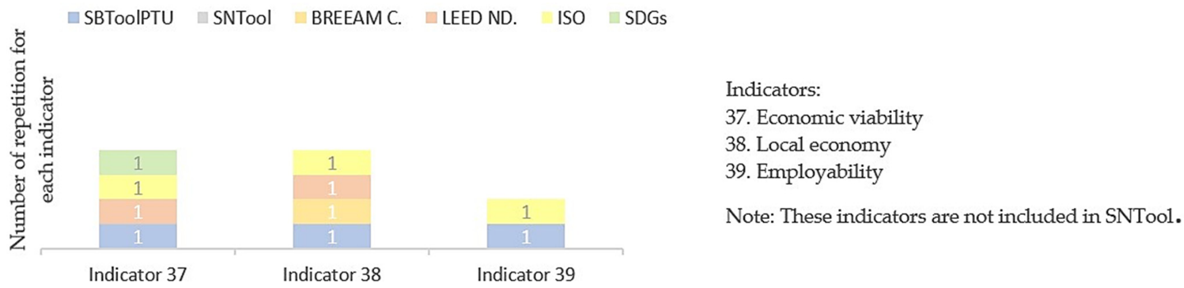

Figure 10. Frequency distribution of each indicator, relevant to the category of employment and economic development in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120, and SDGs.

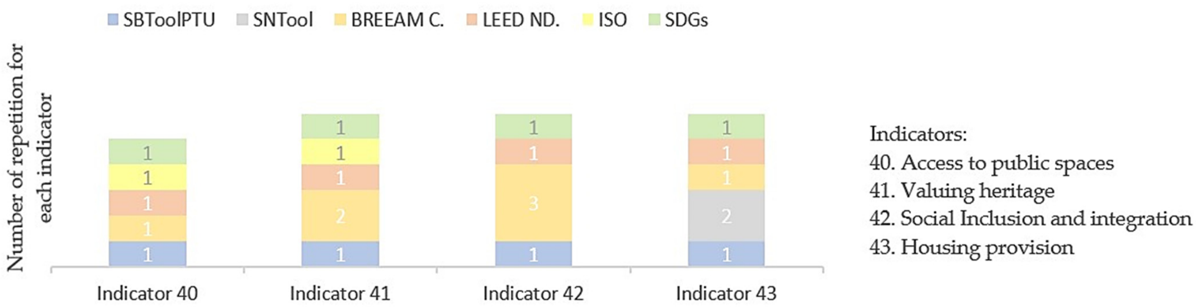

Figure 11. Frequency distribution of each indicator, relevant to the category of local and cultural identity in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120, and SDGs.

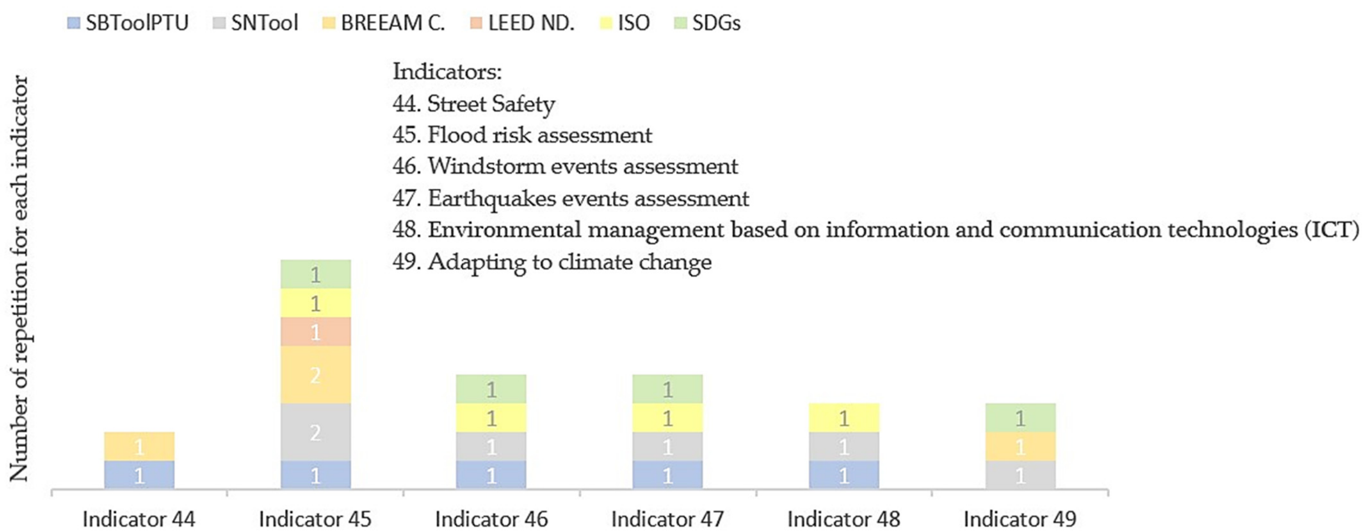

Figure 12. Frequency distribution of each indicator, relevant to the category of context and vulnerabilities in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120, and SDGs.

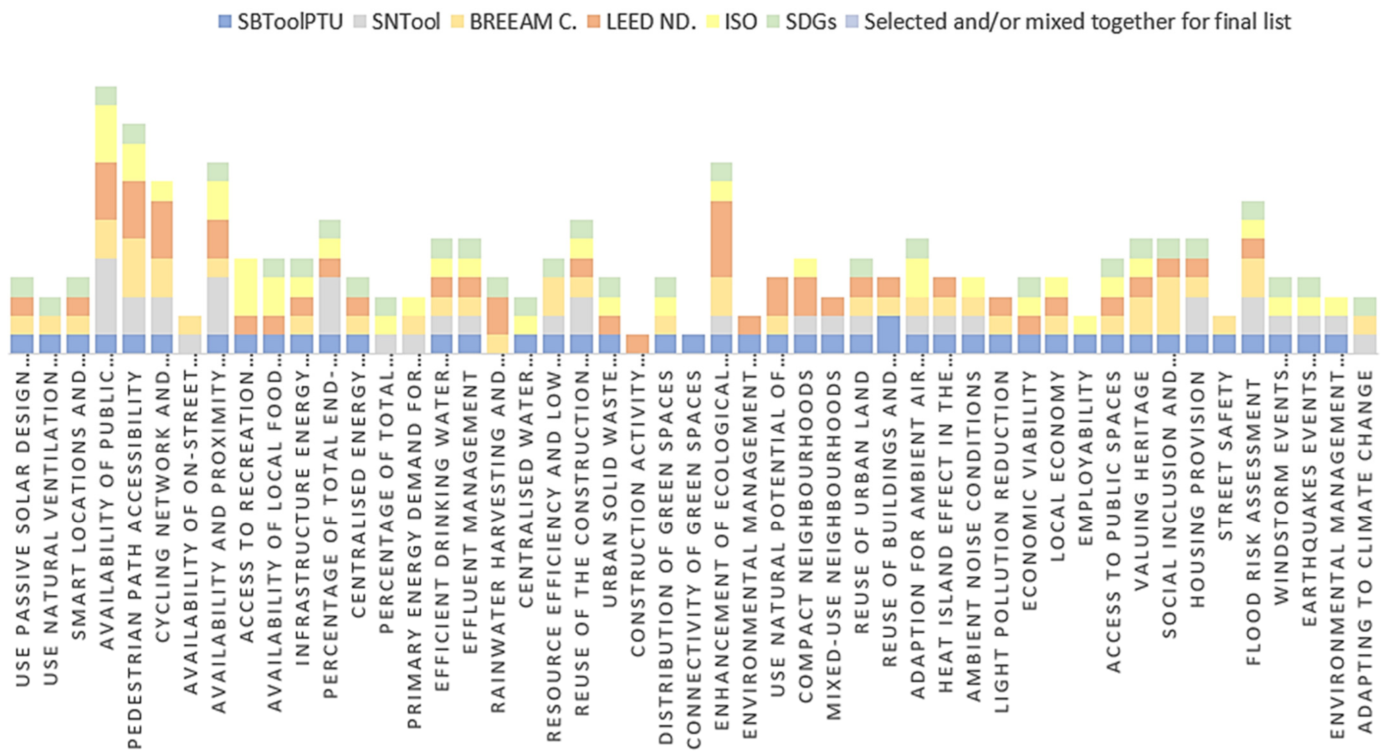

Figure 13. Frequency distribution of each indicator, in SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), ISO 37120, and SDGs.

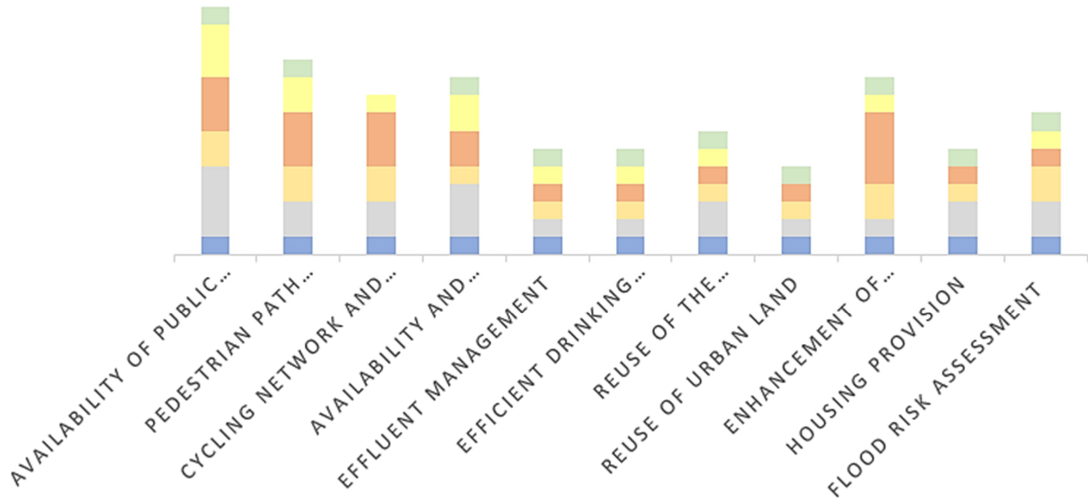

Figure 14. Frequency distribution of each indicator included in the four sustainability tools: SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), and supported by ISO 37120, and/or SDGs.

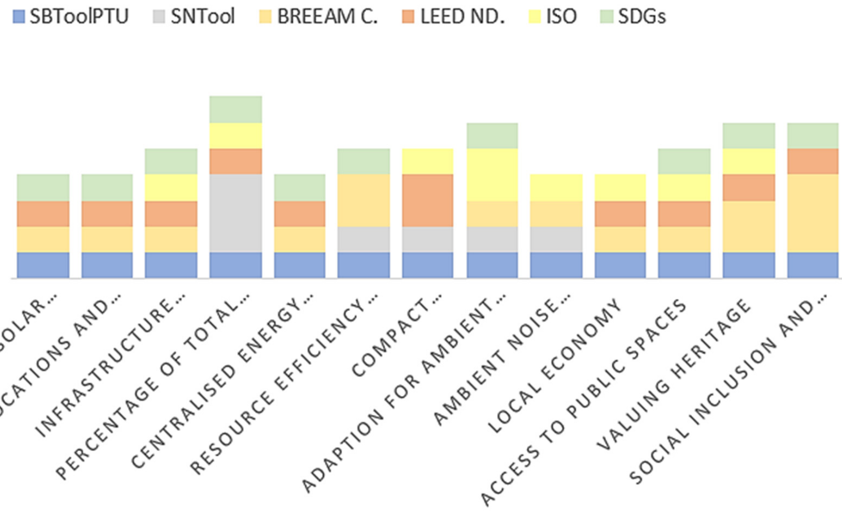

Figure 15. Frequency distribution of each indicator, which are included in the three sustainability tools: SBTool^{PT}_Urban (2018), SNTool Min (2020), BREEAM-C (2012), LEED-ND (2018), and supported by ISO 37120, and/or SDGs.

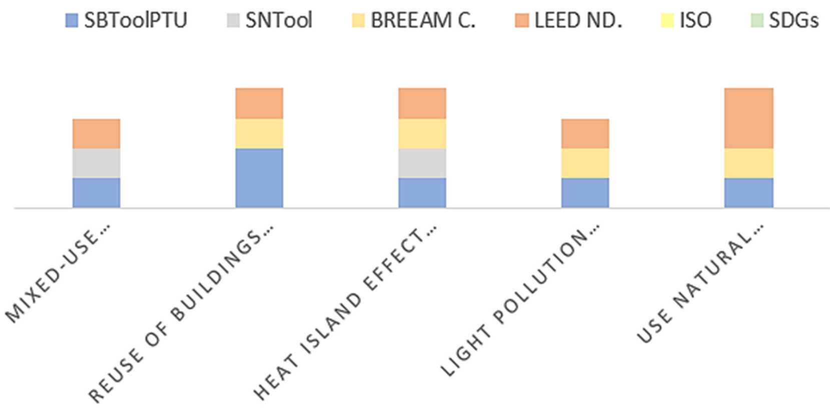

Figure 16. Frequency distribution of each indicator, which is included in three or four sustainability tools: SBTool^{PT}_Urban (2018), SNTool (2020), BREEAM Communities (2012), and LEED-ND (2018).

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.

Author Contributions: Conceptualization, M.S.; methodology, M.S.; validation, M.S.; formal analysis, M.S.; investigation, M.S.; resources, M.S.; data curation, M.S.; writing—original draft preparation, M.S.; writing—review and editing, M.S., L.B. and R.M; visualization, M.S.; supervision, L.B. and R.M.; project administration, L.B. and R.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data used to develop this study are available upon request to the corresponding author.

Conflicts of Interest: The authors declare that there is no conflict of interest.

References

1. Steiniger, S.; Wagemann, E.; de la Barrera, F.; Molinos-Senante, M.; Villegas, R.; de la Fuente, H.; Vives, A.; Arce, G.; Herrera, J.C.; Carrasco, J.A.; et al. Localizing urban sustainability indicators: The CEDEUS indicator set, and lessons from an expert-driven process. *Cities* **2020**, *101*, 102683. [CrossRef]
2. Sharifi, A.; Murayama, A. A critical review of seven selected neighborhood sustainability assessment tools. *Environ. Impact Assess. Rev.* **2013**, *38*, 73–87. [CrossRef]
3. United Nations Human Settlements Program (UN-HABITAT). Planning Sustainable Cities, UN-Habitat Practices and Perspective. 2010. Available online: https://unhabitat.org/planning-sustainable-cities-un-habitat-practices-and-perspectives (accessed on 22 March 2022).
4. Gavrilescu, M. 2.66 Sustainability. *Compr. Biotechnol.* **2011**, *2*, 905–923. [CrossRef]
5. Shen, L.Y.; Ochoa, J.J.; Shah, M.N.; Zhang, X. The application of urban sustainability indicators, A comparison between various practices. *Habitat Int.* **2011**, *35*, 17–29. [CrossRef]
6. CESBA MED for Sustainable MED Cities. CESBA MED Guide, Version 3, D5.3.2. 2019. Available online: https://efficient-buildings.interreg-med.eu/fileadmin/user_upload/Sites/Efficient_Buildings/Projects/CESBA_MED/D5.3.2_CESBA_MED_Guide_English.pdf (accessed on 22 March 2022).
7. Hezri, A.A. Sustainability indicator system and policy processes in Malaysia: A framework for utilisation and learning. *J. Environ. Manag.* **2004**, *73*, 357–371. [CrossRef] [PubMed]
8. Wangel, J.; Wallhagen, M.; Malmqvist, T.; Finnveden, G. Certification systems for sustainable neighborhoods: What do they really certify? *Environ. Impact Assess. Rev.* **2016**, *56*, 200–213. [CrossRef]
9. Berardi, U. Sustainability assessment of urban communities through rating systems. *Environ. Dev. Sustain.* **2013**, *15*, 1573–1591. [CrossRef]
10. Kaur, H.; Garg, P. Urban sustainability assessment tools: A review. *J. Clean. Prod.* **2019**, *210*, 146–158. [CrossRef]
11. Balaras, C.A.; Droutsa, K.G.; Dascalaki, E.E.; Kotoyiannidis, S. Holistic sustainability assessment systems for buildings and neighborhoods. *Zb. Međunarodnog Kongr. O KGH* **2018**, *49*, 239–250. [CrossRef]
12. Balaras, C.A.; Droutsa, K.G.; Dascalaki, E.G.; Kontoyiannidis, S.; Moro, A.; Bazzan, E. A transnational multicriteria assessment method and tool for sustainability rating of the built environment. In Proceedings of the IOP Conference Series: Earth and Environmental Science, Ho Chi Minh City, Vietnam, 29 October 2021.
13. Pires, S.M.; Fidélis, T.; Ramos, T.B. Measuring and comparing local sustainable development through common indicators: Constraints and achievements in practice. *Cities* **2014**, *39*, 1–9. [CrossRef]
14. Quinn, C.; Snell, C. Peter Rogers, Kazi Jalal, & John Boyd, An Introduction to Sustainable Development. *Sustain. Sci. Pract. Policy* **2017**, *4*, 50–51. [CrossRef]
15. Dryzek, J.S. *The Politics of the Earth: Environmental Discourses*, 4th ed.; Oxford University Press: Oxford, MS, USA, 2021. Available online: https://books.google.pt/books?id=sjVKEAAAQBAJ&lpg=PP1&ots=sUkMcf485f&dq=The%20Politics%20of%20the%20Earth%3A%20Environmental%20Discourses&lr&pg=PP1#v=onepage&q=The%20Politics%20of%20the%20Earth:%20Environmental%20Discourses&f=false (accessed on 28 March 2022).
16. Deng, W.; Cheshmehzangi, A. *Eco-Development in China: Cities, Communities and Buildings*; Springer: Berlin/Heidelberg, Germany, 2018. [CrossRef]
17. Fiksel, J.; Eason, T.; Frederickson, H. A Framework for Sustainability Indicators at EPA. Available online: https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NRMRL&dirEntryId=254270 (accessed on 22 August 2021).
18. Merino-Saum, A.; Halla, P.; Superti, V.; Boesch, A.; Binder, C.R. Indicators for urban sustainability: Key lessons from a systematic analysis of 67 measurement initiatives. *Ecol. Indic.* **2020**, *119*, 106879. [CrossRef]

19. Rossi, A. *The Architecture of the City*; MIT Press Cambridge: London, UK, 1982. Available online: https://monoskop.org/images/1/16/Rossi_Aldo_The_Architecture_of_the_City_1982_OCR_parts_missing.pdf (accessed on 22 August 2021).
20. Engel-Yan, J.; Kennedy, C.; Saiz, S.; Pressnail, K. Toward sustainable neighbourhoods: The need to consider infrastructure interactions. *Can. J. Civ. Eng.* **2005**, *32*, 45–57. [CrossRef]
21. Tam, V.W.; Karimipour, H.; Le, K.N.; Wang, J. Green neighbourhood: Review on the international assessment systems. *Renew. Sustain. Energy Rev.* **2018**, *82*, 689–699. [CrossRef]
22. Jacob, K.; Blake, R.; Horton, R.; Bader, D.; O'Grady, M. Chapter 7: Indicators and monitoring. *Ann. N. Y. Acad. Sci.* **2010**, *1196*, 127–142. [CrossRef]
23. Braganca, L.; Mateus, R. *Guia de avaliação SBTool^{PT} Urban, V 2018*; iiSBE Portugal, School of Engineering: Guimaraes, Portugal, 2018; ISBN 978-989-20-8969-0.
24. Borrego, C.; Martins, H.; Tchepel, O.; Salmim, L.; Monteiro, A.; Miranda, A.I. How urban structure can affect city sustainability from an air quality perspective. *Environ. Modeling Softw.* **2006**, *21*, 461–467. [CrossRef]
25. Rickwood, P.; Glazebrook, G.; Searle, G. Urban structure and energy, a review. *Urban Policy Res.* **2008**, *26*, 57–81. [CrossRef]
26. Howie, P.; Murphy, S.M.; Wicks, J. An application of a stated preference method to value urban amenities. *Urban Stud.* **2010**, *47*, 235–256. [CrossRef]
27. Allen, N. Understanding the importance of urban amenities: A case study from Auckland. *Buildings* **2015**, *5*, 85–99. [CrossRef]
28. Partridge, M.; Olfert, M.R.; Alasia, A. Canadian cities as regional engines of growth: Agglomeration and amenities. *Can. J. Econ.* **2007**, *40*, 39–68. [CrossRef]
29. Halseth, G.; Markey, S.; Ryser, L. *Service Provision and Rural Sustainability: Infrastructure and Innovation*, 2nd ed.; Halseth, G., Markey, S., Ryser, L., Eds.; Routledge Taylor & Francis: London, UK; New York, NY, USA, 2019. Available online: http://rem-main.rem.sfu.ca/papers/markey/9781138483736_preview.pdf (accessed on 28 March 2022).
30. iiSBE International and iiSBE Italia. SNTool B Scoring EN Minimum Version. 2020. Available online: http://www.iisbe.org/node/295 (accessed on 22 March 2022).
31. Jones, P.; Comfort, D.; Hillier, D. A case study of local food and its routes to market in the UK. *Br. Food J.* **2004**, *106*, 328–335. [CrossRef]
32. Jia, S.S. Local food campaign in a globalization context: A systematic review. *Sustainability* **2021**, *13*, 7487. [CrossRef]
33. American Chemical Society. What Are the Greenhouse Gas Changes since the Industrial Revolution? ACS Climate Science Toolkit, Greenhouse Gases. Available online: https://www.acs.org/content/acs/en/climatescience/greenhousegases/industrialrevolution.html (accessed on 22 March 2022).
34. Riti, J.S.; Shu, Y. Renewable energy, energy efficiency, and eco-friendly environment (RE 5) in Nigeria. *Energy Sustain. Soc.* **2016**, *6*, 13. [CrossRef]
35. Guney, T. Renewable energy, non-renewable energy, and sustainable development. *Int. J. Sustain. Dev. World Ecol.* **2019**, *26*, 389–397. [CrossRef]
36. Michaelowa, A.; Wentrup, K.; Köhler, M.; Wehner, S.; Kumar, E.; Subramaniyam, A.; Verma, A.; Munzinger, P.; Purba, E.; Katriana, T. Smart Street Lighting Initiative NAMA Implementation Plan. Available online: https://www4.unfccc.int/sites/PublicNAMA/_layouts/UN/FCCC/NAMA/Download.aspx?ListName=NAMA&Id=55&FileName=GIZ%20ESDM%20SSLI%20NAMA%20IP%20final.pdf (accessed on 22 March 2022).
37. Krarti, M. Optimal Design and Retrofit of Energy Efficient Buildings. In *Communities, and Urban Centers*; Butterworth-Heinemann: Cambridge, MA, USA, 2018; pp. 1–43. [CrossRef]
38. Segatto, M.E.; de Oliveira Rocha, H.R.; Silva, J.A.; Paiva, M.H.; Cruz, M.A. Telecommunication technologies for smart grids: Total cost optimization. *Adv. Renew. Energ. Power Technol.* **2018**, *2*, 451–478. [CrossRef]
39. Lopez., G. Málaga Smart City: A Wide Range of Solutions for Local Energy Sustainability, Public Sector Transparency, and Open Government. Available online: https://joinup.ec.europa.eu/collection/open-government/document/malaga-smart-city-wide-range-solutions-local-energy-sustainability-public-sector-transparency-and (accessed on 22 March 2022).
40. Farmanbar, M.; Parham, K.; Arild, Q.; Rong, C. A widespread review of smart grids towards smart cities. *Energies* **2019**, *12*, 4484. [CrossRef]
41. Lal, R. World water resources and achieving water security. *Agron. J.* **2015**, *107*, 1526–1532. [CrossRef]
42. Rost, S.; Gerten, D.; Bondeau, A.; Lucht, W.; Rohwer, J.; Schaphoff, S. Agricultural green and blue water consumption and its influence on the global water system. *Water Resour. Res.* **2008**, *4*, W09405. [CrossRef]
43. Cutore, P.; Campisano, A.; Kapelan, Z.; Modica, C.; Savic, D. Probabilistic prediction of urban water consumption using the SCEM-UA algorithm. *Urban Water J.* **2008**, *5*, 125–132. [CrossRef]
44. NSW Government. *Effluent Reuse Management, Strategic Environmental Compliance, and Performance Review*; Department of Environment and Climate Change and Water: Sydney, Australia, 2010. Available online: https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/licensing/10824effluentreusereport.pdf (accessed on 22 March 2022).
45. SDG Indicators. Global Indicator Framework for the Sustainable Development Goals and Targets of the 2030 Agenda for Sustainable Development. UN Sustainable Development Goals. Available online: https://unstats.un.org/sdgs/indicators/indicators-list/ (accessed on 22 March 2022).

46. Hermawan, F. Optimization of transportation of municipal solid waste from resource to intermediate treatment facility with nearest neighbour method (Study on six sub district in DKI Jakarta province). *J. Environ. Sci. Sustain. Dev.* **2018**, *1*, 86–99. [CrossRef]
47. Chi, Y.; Dong, J.; Tang, Y.; Huang, Q.; Ni, M. Life cycle assessment of municipal solid waste source-separated collection and integrated waste management systems in Hangzhou, China. *J. Mater. Cycles Waste Manag.* **2015**, *17*, 695–706. [CrossRef]
48. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Roadmap to a Resource Efficient Europe. Available online: https://www.europarl.europa.eu/meetdocs/2009_2014/documents/com/com_com(2011)0571_/com_com(2011)0571_en.pdf (accessed on 22 March 2022).
49. BRANZ. Designing for Waste Minimization. Available online: https://www.branz.co.nz/sustainable-building/reducing-building-waste/planning/designing-waste-minimisation/ (accessed on 22 March 2022).
50. Kowarik, I.; Fischer, L.K.; Kendal, D. Biodiversity conservation and sustainable urban development. *Sustainability* **2020**, *12*, 4964. [CrossRef]
51. Divinsky, I.; Becker, N.; Bar, P. Ecosystem service tradeoff between grazing intensity and other services- A case study in Karei-Deshe experimental cattle range in northern Israel. *Ecosyst. Serv.* **2017**, *24*, 16–27. [CrossRef]
52. Wilson, E.O.; WW Norton & Company. Half-Earth: Our Planet's Fight for Life. 2016. Available online: https://books.google.pt/books?hl=en&lr=&id=gft1CQAAQBAJ&oi=fnd&pg=PT6&dq=Half-Earth:+Our+Planet%27s+Fight+for+Life&ots=VeMBauvn2T&sig=CnPzNg0ibjy1WNmoxeDcEHxGOZY&redir_esc=y#v=onepage&q=Half-Earth%3A%20Our%20Planet\T1\textquoterights%20Fight%20for%20Life&f=false (accessed on 28 March 2022).
53. Karuniasa, M.; Prambudi, P.A. Transition of primary forest to secondary forest and the impact for water resources conservation. *J. Environ. Sci. Sustain. Dev.* **2019**, *2*, 15–25. [CrossRef]
54. Wei, Y.D. Urban land, and sustainable development, Towards equitable and sustainable urban space: Introduction to Special Issue on urban land and sustainable development. *Sustainability* **2016**, *8*, 804. [CrossRef]
55. Treija, S.; Bratuškins, U.; Koroļova, A. Urban densification of large housing estates in the context of Privatisation of public open space: The case of Imanta, Riga. *Archit. Urban Plan.* **2018**, *14*, 105–110. [CrossRef]
56. Teller, J. Regulating urban densification: What factors should be used? *Build. Cities* **2021**, *2*, 302–317. [CrossRef]
57. U.S. Green Building Council. LEED v4, for Neighborhood Development. 2018. Available online: https://www.usgbc.org/resources/leed-v4-neighborhood-development-current-version (accessed on 22 March 2022).
58. European Environment Agency. Indicator Specification, Land Recycling, and Densification. 2018. Available online: https://www.eea.europa.eu/data-and-maps/indicators/land-recycling-and-densification (accessed on 22 March 2022).
59. Ahmed, R.M.; Alibaba, H.Z. An evaluation of green roofing in buildings. *Int. J. Sci. Res. Publ.* **2016**, *6*, 366–373.
60. Frimawaty, E.; Kamiluddin, M.M. Living room ventilation and urban environmental health case in DKI Jakarta. *J. Environ. Sci. Sustain. Dev.* **2020**, *3*, 7–31. [CrossRef]
61. EPA Unitet States, Environmental Protection Agency. Particulate Matter (PM2.5) Trends. Available online: https://www.epa.gov/air-trends/particulate-matter-pm25-trends (accessed on 22 March 2022).
62. CDC Centers for Disease Control and Prevention. CDC 24/7 Saving Lives, Protecting People. Air Quality, Particle Pollution. 2019. Available online: https://www.cdc.gov/air/particulate_matter.html (accessed on 22 March 2022).
63. European Commission, Joint Research Centre (JRC). Urban Air Pollution: What Are the Main Sources across the World? *ScienceDaily*. 2015. Available online: www.sciencedaily.com/releases/2015/12/151201094112.htm (accessed on 22 March 2022).
64. Chang, L.T.; Scorgie, Y.; Duc, H.N.; Monk, K.; Fuchs, D.; Trieu, T. Major source contributions to ambient PM2. 5 and exposures within the New South Wales greater metropolitan region. *Atmosphere* **2019**, *10*, 138. [CrossRef]
65. EPA United States, Environmental Przotection Agency. EPA to Reexamine Health Standards for Harmful Soot that Previous Administration Left Unchanged. 2021. Available online: https://www.epa.gov/newsreleases/epa-reexamine-health-standards-harmful-soot-previous-administration-left-unchanged (accessed on 22 March 2022).
66. Stone, B., Jr. *The City and the Coming Climate: Climate Change in the Places We Live*; Cambridge University Press: New York, NY, USA, 2012.
67. Larsson, N. iiSBE SNTool for performance assessment of urban neighborhoods. In Proceedings of the Meeting of International Urban Framework Committee (IUFC), Scilla, Italy, 16–17 May 2019. [CrossRef]
68. Lee, S. Transport policies, induced traffic and their influence on vehicle emissions in developed and developing countries. *Energy Policy* **2018**, *121*, 264–274. [CrossRef]
69. Katz, Y.; Levin, N. Quantifying urban light pollution, A comparison between field measurements and EROS-B imagery. *Remote Sens. Environ.* **2016**, *177*, 65–77. [CrossRef]
70. Azman, M.I.; Dalimin, M.N.; Mohamed, M.; Bakar, M.A. A brief overview on light pollution. In Proceedings of the IOP Conference Series: Earth and Environmental Science, Johor Darul Takzim, Malaysia, 11–13 November 2019. [CrossRef]
71. BREEAM Communities. Technical Manual SD202. Available online: https://www.breeam.com/communitiesmanual/#resources/otherformats/output/10_pdf/20_a4_pdf_screen/sd202_breeam_communities_1.2_screen.pdf (accessed on 22 March 2022).
72. Cui, P.; Mao, Y.; Shen, Y.; Ma, J. Moral identity and subjective well-being: The mediating role of identity commitment quality. *Int. J. Environ. Res. Public Health* **2021**, *18*, 9795. [CrossRef] [PubMed]
73. Rayfield, F.; Cabana, D.; Brannigan, J.; Crowe, T. Conceptualizing sense of place in cultural ecosystem services: A framework for interdisciplinary research. *Ecosyst. Serv.* **2019**, *36*, 100907. [CrossRef]

74. The Right to Adequate Housing, Fact Sheet No. 21/Rev.1. Available online: https://unhabitat.org/sites/default/files/download-manager-files/Right%20to%20adequate%20housing.pdf (accessed on 22 March 2022).
75. Oxfam International. 5 Natural Disasters that Beg for Climate Action. Available online: https://www.oxfam.org/en/5-natural-disasters-beg-climate-action#:~{}:text=We\T1\textquoterightve%20always%20had%20hurricanes,wildfires%2C%20flooding%20and%20high%20winds (accessed on 22 March 2022).