NORMATIVE HOUSING INDICATORS AND THEIR CONTRIBUTION TO THE SUSTAINABLE DEVELOPMENT GOALS

INDICADORES HABITACIONAIS NORMATIVOS E SUA CONTRIBUIÇÃO PARA OS OBJETIVOS DE DESENVOLVIMENTO SUSTENTÁVEL

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Abstract
This article analyzes the role of housing in sustainable development, highlighting its relevance in mitigating climate change and improving quality of life. The research examines normative indicators established by ISO standards 37.120, 37.122, and 37.123, as well as the criteria of NBR 15.575 and the INI-R Normative Instruction, demonstrating their alignment with the Sustainable Development Goals (SDGs). The results show that these indicators not only address the accessibility and adequacy of housing but also promote inclusive and resilient cities. The adoption of sustainable practices and energy efficiency technologies is crucial for achieving the SDGs, particularly those related to poverty eradication and building sustainable communities. The research concludes that integrating these indicators into housing policies is essential for sustainable urban development.
Keywords: housing, sustainable development, sustainable development goals, energy efficiency.

Resumo
Este artigo analisa o papel da habitação no desenvolvimento sustentável, destacando sua relevância na mitigação das mudanças climáticas e na melhoria da qualidade de vida. A pesquisa examina indicadores normatizados pelas normas ISO 37.120, 37.122 e 37.123, além dos critérios da NBR 15.575 e da Instrução Normativa INI-R, evidenciando seu alinhamento com os Objetivos de Desenvolvimento Sustentável (ODS). Os resultados mostram que esses indicadores não apenas abordam a acessibilidade e adequação das moradias, mas também promovem cidades inclusivas e resilientes. A adoção de práticas sustentáveis e tecnologias de eficiência energética

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é crucial para atingir os ODS, especialmente os relacionados à erradicação da pobreza e à construção de comunidades sustentáveis. A pesquisa conclui que integrar esses indicadores nas políticas habitacionais é fundamental para um desenvolvimento urbano sustentável.
Palavras-chave: habitação, desenvolvimento sustentável, objetivos de desenvolvimento sustentável, eficiência energética.

Introduction

According to the latest assessment report of the Intergovernmental Panel on Climate Change (IPCC) in 2019, buildings were responsible for 21% of global Greenhouse Gas (GHG) emissions (IPCC, 2021). Recent research indicates that climate change mitigation in buildings can also have substantial social and economic value, in addition to reducing energy consumption and mitigating GHG emissions (IEA, 2014; Kamal et al., 2019; Bleyl et al., 2019; Mirasgedis, Cabeza and Vérez, 2024). Thus, sustainable development has become a constant concern, and housing plays a fundamental role in this process of reducing these impacts.

Sustainable development has been discussed in the international community since the 1980s, with this term first used by the United Nations (UN) World Commission on Environment and Development, which published the Brundtland Report, entitled "Our Common Future," highlighting the concern for sustainable development and economic and social growth (UN Brazil, 2020). However, in 2015, during the United Nations Sustainable Development Summit held in New York, the 2030 Agenda was launched, with the main objective of reducing hunger and poverty, minimizing the effects of climate change, and seeking more equality and quality of life for people.

The 2030 Agenda establishes the 17 Sustainable Development Goals (SDGs) (UN Brazil, 2020). These goals are interconnected and accompanied by targets and indicators, with the purpose of guiding and monitoring their progress and advancement, addressing the most urgent socio-environmental challenges in promoting sustainable development by 2030. In this context, the adoption of the SDGs proposed by the 2030 Agenda becomes important, especially regarding climate change mitigation, cities, and buildings.

To understand the centrality of housing in the context of the SDGs, we associate housing with sustainable development through three dimensions defined by Jamuladin et al. (2018) and UN Habitat (2012): i) social, which treats housing as a promoter of a sense of belonging to a community and not just as a shelter; ii) economic, which concerns the ownership of housing by families, in addition to its construction contributing to job creation; and iii) environmental, which deals with housing being resilient, able to potentially reduce GHG emissions through improved energy efficiency. Furthermore, the implementation of mitigation actions in buildings has many other impacts, mainly for residents, the economy, and society.

The International Organization for Standardization (ISO), in 2013, noted a growing concern with the theme of sustainable, green, resilient, or smart cities and communities, and thus created the Technical Committee on "Sustainable cities and communities" (ISO, 2013). Since its creation, ISO has already published three standards, the first focused exclusively on sustainable development in communities, namely: ISO 37100:2016 (ABNT, 2021) - Sustainable cities and communities - Vocabulary and ISO 37101:2016 (ABNT, 2021) - Sustainable cities and communities - Management system for sustainable development - Requirements with guidance for use. In addition to these, other standards have been developed and published, such as ISO 37120:2018 (ABNT,
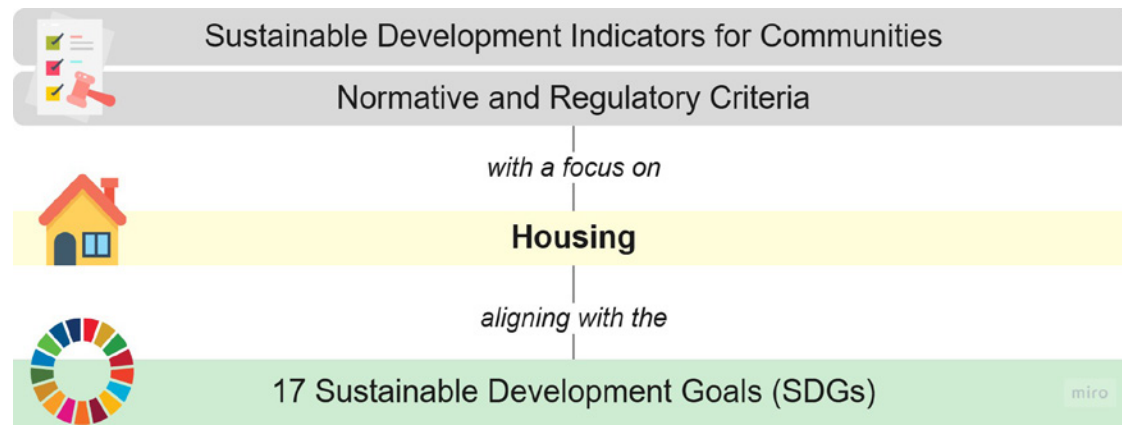
2021) - Sustainable cities and communities - Indicators for city services and quality of life, focusing on smart cities, and ISO 37123:2019 (ABNT, 2021) - Sustainable cities and communities - Indicators for resilient cities, focusing on resilient cities. These ISO standards present essential and supporting indicators to help cities and communities evaluate their performance in relation to sustainable development, resilience, and intelligence goals. These standards have become important references for the planning and management of more sustainable cities and communities.

The advancement of ISO standardization is an important effort in the pursuit of more sustainable cities. As a consequence, it can generate direct and indirect effects on dimensions contained in the SDGs, both in specific indicators contained in the climate action targets and in potential developments on other SDGs. Mainly, the contribution of the ISO 37.120 (ABNT, 2021), 37.122 (ABNT, 2021), and 37.123 (ABNT, 2021) standards in relation to the SDGs is still a gap in the literature.

Furthermore, in Brazil, NBR 15.575:2013 (ABNT, 2021) - Residential buildings - Requirements for the performance of buildings and the INMETRO Normative Instruction for Residential Buildings (INI-R - Brazil, 2022) are two important normative instruments that regulate fundamental aspects related to residential buildings. NBR 15.575:2013 (ABNT, 2021) establishes minimum performance requirements for various construction elements, addressing issues of safety, habitability, and sustainability of housing. INI-R (Brazil, 2022), in turn, defines energy efficiency criteria to be met by residential buildings, aiming to reduce energy consumption and adopt more sustainable solutions. These standards play a crucial role in the construction industry by establishing quality, safety, and sustainability standards that must be observed in the development of projects and the construction of new homes. Their implementation has the potential to generate positive impacts on the quality of life of residents, the mitigation of the effects of climate change, and, mainly, the achievement of the SDG targets and goals.

In this context, this research aims to analyze the alignment between the housing-related indicators established in the ISO 37.120, ISO 37.122, and ISO 37.123 standards and the thermal, acoustic, lighting, and energy efficiency performance criteria defined in NBR 15.575 and INI-R, in order to identify their contribution to the achievement of the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda.

Methodology

The methodological process consists of three stages: i) survey of indicators using the ISO 37.120 (ABNT, 2021), ISO 37.122 (ABNT, 2021), and ISO 37.123 (ABNT, 2021) standards, ii) survey of thermal, acoustic, lighting, and energy efficiency performance criteria and requirements for housing using NBR 15.575 (ABNT, 2021) and INI-R (Brazil,
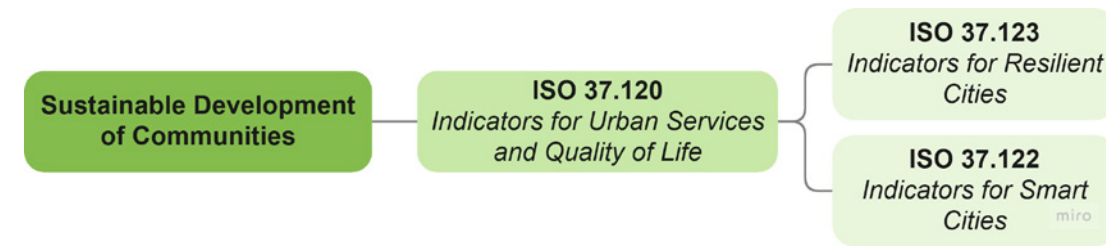
2022), and iii) analysis of the alignment of these indicators, with a focus on housing, with the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda (Figure 01).

Standardized ISO Indicators Related to Housing in Sustainable Cities and Communities

For the survey of indicators, the following standards were used: ISO 37.120 (ABNT, 2021), entitled "Sustainable Cities and Communities - Indicators for Urban Services and Quality of Life", ISO 37.122 (ABNT, 2021), which deals with "Sustainable Cities and Communities - Indicators for Smart Cities", and ISO 37.123 (ABNT, 2021), whose title is "Sustainable Cities and Communities - Indicators for Resilient Cities". These ISO standards were created with the aim of providing a standardized set of indicators for sustainable, smart, and resilient cities and communities (Figure 02).

From the ISO standards, the indicators that have a direct or indirect relationship with housing, the focus of the study, were selected. The housing-related indicators in ISO 37.120 (ABNT, 2021) are presented in the "Housing" dimension, being separated into core indicators, such as: i) percentage of the city's population living in inadequate housing and ii) percentage of the population living in economically affordable housing. The supporting indicators are: i) number of homeless people per 100,000 population and ii) percentage of dwellings without registered property titles. In addition, ISO 37.120 (ABNT, 2021) also presents the indicator of total number of households, which is a characteristic indicator.

In ISO 37.122 (ABNT, 2021), the housing-related indicators are presented in two dimensions: in the "Housing" dimension, there are i) percentage of households with smart energy meters and ii) percentage of households with smart water meters; and in the "Infrastructure and Buildings" dimension, the indicators i) percentage of buildings in the city with smart energy meters and ii) percentage of buildings built or renovated in the last five years in accordance with green building principles can be considered.

Finally, in ISO 37.123 (ABNT, 2021), the indicators that have a direct impact on housing are in the "Housing" dimension: i) percentage of structurally vulnerable buildings to high-risk threats; ii) percentage of residential buildings non-compliant with building codes and standards; iii) annual number of flooded residential properties as a percentage of total residential properties in the city; and iv) percentage of residential properties located in high-risk areas.

The ISO 37.122 (ABNT, 2021) and ISO 37.123 (ABNT, 2021) standards do not present a classification of importance (core or supporting) for each indicator. However, the indicators can be interpreted as core when they have a direct impact on quality of

life and housing conditions, while those that contribute to improving infrastructure and accessibility can be considered supporting.

In addition to the indicators listed in the respective dimensions of the ISO 37.120 (ABNT, 2021), ISO 37.122 (ABNT, 2021) and ISO 37.123 (ABNT, 2021) standards, in other dimensions, there are indicators that may be relevant for housing (Table 1).

ISO 37.120 (ABNT, 2021)	
Dimension	Relevant Indicators for Housing
Safety	Crime rate
Transportation	Access to public transportation
Education	Number of schools per 100,000 inhabitants
Environment	Air quality
Environment	Percentage of green areas
Health	Number of hospital beds per 100,000 inhabitants
Economy	Unemployment rate
ISO 37.122 (ABNT, 2021)	
Dimension	Relevant Indicators for Housing
Environment	Percentage of green areas
Health	Number of hospital beds per 100,000 inhabitants
Transportation	Access to public transportation
Safety	Crime rate
ISO 37.122 (ABNT, 2021)	
Dimension	Relevant Indicators for Housing
Infrastructure	Percentage of damaged infrastructure that was "rebuilt better" after a disaster
Environment	Percentage of green areas
Health	Number of hospital beds per 100,000 inhabitants
Transportation	Access to public transportation
Safety	Crime rate
Climate Change	Annual frequency of extreme events (storms, heat, cold)

Finally, the housing-related indicators selected from the ISO 37.120 (ABNT, 2021), ISO 37.122 (ABNT, 2021) and ISO 37.123 (ABNT, 2021) standards will be analyzed in relation to the 17 Sustainable Development Goals (SDGs) of the UN 2030 Agenda. In order to evaluate the alignment of each housing indicator with the respective targets of the 17 SDGs, the aim is to discuss the relevance of these indicators in the implementation of effective public policies for the sustainable development of cities.

Housing Indicators Based on Brazilian Standards and Regulations

In Brazil, NBR 15.575 (ABNT, 2021) establishes performance requirements and criteria applicable to residential buildings, being divided into six parts. The main objective of this standard is to establish performance requirements and criteria to meet the requirements of users of residential buildings, regardless of the constituent materials and the construction system used. NBR 15.575 (ABNT, 2021) covers three main areas related to housing: safety, habitability, and sustainability, which aim to guide the development of suitable technical solutions that meet the requirements of users in an objective and measurable way, contributing to the improvement of the quality of residential buildings in Brazil (Figure 03).
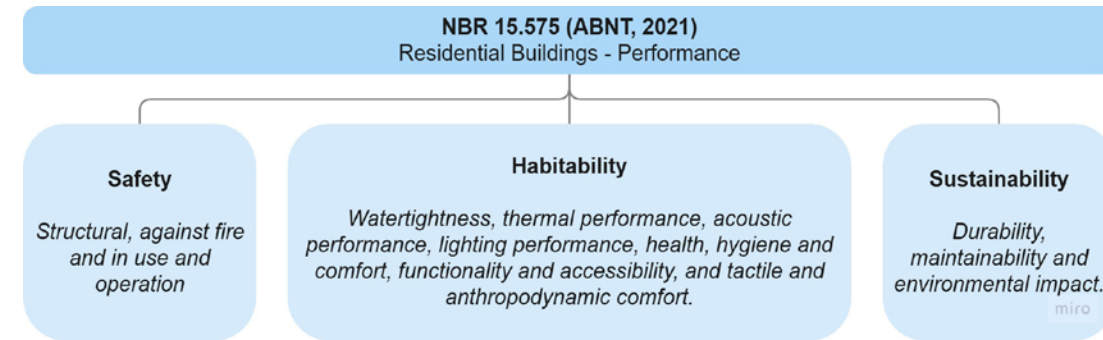
NBR 15.575 (ABNT, 2021)
Residential Buildings - Performance

Safety
Structural, against fire and in use and operation

Habitability
Watertightness, thermal performance, acoustic performance, lighting performance, health, hygiene and comfort, functionality and accessibility, and tactile and anthropodynamic comfort.

Sustainability
Durability, maintainability and environmental impact.

The INMETRO Normative Instruction for Energy Efficiency of Residential Buildings (INI-R) establishes the criteria and methods for classifying the energy efficiency of residential buildings, with the aim of promoting the labeling of residential buildings in Brazil. In addition, INI-R (Brazil, 2022) uses some requirements established in NBR 15.575 (ABNT, 2021) in its prescriptive assessment method. INI-R (Brazil, 2022) covers three assessment methods for residential housing, allowing to survey performance and energy efficiency criteria: the prescriptive method, the simplified method, and the simulation method (Figure 03). These methods aim to assess the building envelope and the energy consumption of air conditioning and water heating systems. In addition, INI-R (Brazil, 2022) also presents evaluation criteria related to housing, such as local generation of renewable energy, carbon dioxide emissions, rational use of water, and common areas of multi-family buildings or condominiums, considering their systems, such as lighting, pump systems, and elevators.

Although NBR 15.575 (ABNT, 2021) and INI-R (Brazil, 2022) do not present indicators per se, they establish performance and energy efficiency requirements and criteria applicable to residential buildings. For the purposes of this research, it is considered that such requirements and criteria can be used as indicators to evaluate the performance of residential buildings. Therefore, only those that have a direct relationship with the thermal, acoustic, lighting, and energy efficiency performance of housing were selected (Table 2).

NBR 15.575 (ABNT, 2021)	
Dimension	Possible indicators
Thermal performance	Percentage of occupancy hours within an operative temperature range (PHFT)
Thermal performance	Maximum annual operative temperature (TomaxUH)
Thermal performance	Minimum annual operative temperature (TominUH)
Thermal performance	Total thermal load (CgTTUH)
Acoustic performance	Airborne sound insulation of external envelope systems
Acoustic performance	Airborne sound insulation of floor and internal vertical envelope systems
Acoustic performance	Impact sound insulation of floor systems
Lighting performance	Minimum levels of natural illuminance
Lighting performance	Daylight factor (FLD)
Lighting performance	Minimum levels of artificial lighting

INI-R (Brasil, 2022)	
Dimension	**Possible indicators**
Envelope	Percentage of occupancy hours within an operative temperature range (PHFT)
	Maximum annual operative temperature (TomaxUH)
	Minimum annual operative temperature (TominUH)
	Total thermal load (CgTTUH)

This consideration of the requirements and criteria of NBR 15.575 (ABNT, 2021) and INI-R (Brazil, 2022) aims to analyze the relationship between the normative requirements and criteria and the 17 SDGs. This analysis aims to identify how these normative guidelines can contribute to the promotion of more sustainable buildings and better quality of life for the occupants. In addition, this investigation may contribute to the development of strategies and solutions aimed at further improving the performance and energy efficiency of residential buildings in Brazil.

Results and Discussions

Alignment of Standardized ISO Housing-Related Indicators with the Sustainable Development Goals

Housing plays a fundamental role in the sustainable development of cities, directly impacting social, economic, and environmental aspects. In this context, the evaluation of housing-related indicators becomes essential to support the planning and implementation of public policies aimed at improving the quality of life of the population. Thus, the results of the analysis of the alignment between the indicators of the ISO standard family and the SDGs are presented, seeking to understand how these indicators can contribute to the achievement of the sustainable development goals established in the 2030 Agenda.

The housing-related indicators from ISO 37.120 (ABNT, 2021) demonstrate a significant alignment with SDG 1, which addresses Poverty Eradication (Table 03). This shows the concern of these indicators in addressing fundamental aspects for the promotion of adequate and affordable housing for the population, directly contributing to poverty reduction.

The indicator of the percentage of the population living in inadequate housing is a crucial indicator, as it reflects the housing conditions of the population, often associated with situations of social and economic vulnerability. This indicator allows the identification of population segments that lack access to decent housing, supporting the planning of public policies aimed at improving housing conditions. The indicator of the percentage of the population living in economically affordable housing addresses the issue of financial accessibility to housing. This aspect is essential to ensure that the low-income population has access to adequate housing, avoiding situations of poverty and social exclusion related to the inability to afford housing costs.

The number of homeless people per 100,000 population is an indicator that directly reflects the situation of extreme poverty, in which people do not have access to minimum housing. This indicator is essential to identify the magnitude of the homelessness problem and support actions aimed at providing housing and support services for the homeless population. Finally, the indicator of the percentage of dwellings without registered property titles also aligns with SDG 1, as the lack of land regularization can expose families to situations of vulnerability, such as forced evictions and difficulties in accessing government programs and benefits.

The housing and building-related indicators from ISO 37.120 (ABNT, 2021), ISO 37.1200 (ABNT, 2021), and ISO 37.123 (ABNT, 2021) demonstrate a significant alignment with SDG 11, which addresses Sustainable Cities and Communities, contributing to the promotion of more inclusive, safe, resilient, and sustainable cities (Table 03).

The indicator of the total number of households from ISO 37.120 (ABNT, 2021) is essential to understand the size and dynamics of the housing sector in cities. This data is essential for the planning and implementation of public policies aimed at the provision of adequate housing, aligning with target 11.1 of SDG 11, which aims to ensure access for all to safe, adequate, and affordable housing.

In ISO 37.122 (ABNT, 2021), the indicator of the percentage of buildings built or renovated in the last five years in accordance with green building principles evaluates the degree of adoption of sustainable practices in the construction industry. This indicator contributes to the promotion of more resilient cities with lower environmental impact, aligning with target 11.b of SDG 11, which aims to substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans for inclusion, resource efficiency, mitigation and adaptation to climate change, and resilience to disasters.

The indicators directly related to housing in ISO 37.123 (ABNT, 2021) are all aligned with SDG 11 (Table 03). The indicator related to the percentage of structurally vulnerable buildings to high-risk threats is essential to identify the vulnerability of buildings to natural disasters and other risks, allowing the development of mitigation and adaptation strategies to make cities safer and more resilient. This indicator is aligned with target 11.5 of SDG 11, which aims to significantly reduce the number of deaths and the number of people affected by disasters. The percentage of residential buildings non-compliant with building codes and standards reflects the quality and safety of buildings, which is a crucial aspect for the promotion of adequate and safe housing. This indicator contributes to the achievement of target 11.1 of SDG 11 by supporting actions aimed at improving housing conditions.

Finally, the indicator of the annual number of flooded residential properties as a percentage of total residential properties in the city and the percentage of residential properties located in high-risk areas are indicators that demonstrate the vulnerability of housing to extreme weather events and natural disasters. These indicators are aligned with target 11.5 of SDG 11, as they contribute to the reduction of the impacts of disasters in cities.

ISO 37.122 (ABNT, 2021) presents two indicators related to the use of smart energy meters, demonstrating a significant alignment with SDG 7, which addresses Affordable and Clean Energy. While the indicator related to the use of smart water meters is aligned with SDG 6, which addresses Clean Water and Sanitation. These indicators reflect the degree of adoption of technologies and practices that contribute to the promotion of more sustainable and resource-efficient cities (Table 03).

Regarding SDG 7, the percentage of households with smart energy meters and the percentage of buildings in the city with smart energy meters are indicators that are directly aligned with target 7.1, which aims to ensure universal, reliable, modern, and affordable access to energy services. These indicators allow monitoring the degree of adoption of technologies that enable better energy management and efficiency, contributing to the promotion of cities with greater energy sustainability. In addition, these indicators are also related to target 7.3 of SDG 7, which aims to double the global rate of improvement in energy efficiency. The use of smart energy meters enables the monitoring and control of energy consumption, allowing the implementation of strategies and actions aimed at

reducing consumption and promoting energy efficiency in households and buildings.

Regarding SDG 6, the percentage of households with smart water meters is directly aligned with target 6.4, which aims to substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity. This indicator allows monitoring the degree of adoption of technologies that enable better water management and efficiency, contributing to the promotion of cities with greater water sustainability.

ISO	ISO-Related Indicators Directly Linked to Housing	SDG
ISO 37.120 (ABNT, 2021)	Percentage of the city's population living in inadequate housing	No Poverty (1)
	Percentage of the population living in economically affordable housing	
	Number of homeless people per 100,000 inhabitants	
	Percentage of dwellings without registered property titles	
	Total number of households	Sustainable Cities and Communities (11)
ISO 37.122 (ABNT, 2021)	Percentage of households with smart energy meters	Affordable and Clean Energy (7)
	Percentage of buildings in the city with smart energy meters	
	Percentage of households with smart water meters	Clean Water and Sanitation (6)
	Percentage of buildings constructed or renovated in the last five years in compliance with green building principles	Sustainable Cities and Communities (11)
ISO 37.123 (ABNT, 2021)	Percentage of structurally vulnerable buildings to high-risk threats	Sustainable Cities and Communities (11)
	Percentage of residential buildings not in compliance with building codes and standards	
	Annual number of flooded residential properties as a percentage of the total residential properties in the city	
	Percentage of residential properties located in high-risk areas	

The indicators from the ISO standards related indirectly to housing show a diverse alignment, presenting three indicators aligned with SDG 3, SDG 11, SDG 15, and SDG 16, and one indicator in each ISO aligned with SDG 4, SDG 8, and SDG 13.

The indicators related to the number of hospital beds per 100,000 population, present in the ISO 37.120 (ABNT, 2021), ISO 37.122 (ABNT, 2021), and ISO 37.123 (ABNT, 2021) standards, demonstrate a significant alignment with SDG 3, which addresses Good Health and Well-Being (Table 04). These indicators provide crucial information about the capacity and availability of hospital infrastructure to meet the health needs of the population. They are directly aligned with target 3.8 of SDG 3, which aims to achieve universal health coverage, including access to quality essential health services and access to safe, effective, quality, and affordable essential medicines and vaccines for all.

The indicators related to air quality in ISO 37.120 (ABNT, 2021), the percentage of damaged infrastructure that was "rebuilt better" after a disaster in ISO 37.123 (ABNT, 2021), and access to public transportation present in the three ISO standards, demonstrate a strong alignment with SDG 11, which addresses Sustainable Cities and Communities (Table 04).

The air quality indicator is directly aligned with target 11.6 of SDG 11, which aims to reduce the negative per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management. This indicator provides crucial information about air pollution in urban areas, allowing the monitoring and implementation of public policies aimed at improving air quality, which is essential for the health and well-being of housing residents.

The indicators related to access to public transportation are aligned with target 11.2 of SDG 11, which aims to provide access to safe, affordable, accessible, and sustainable transport systems for all, improving road safety, with special attention to the needs of those in vulnerable situations. These indicators provide information on the availability and coverage of public transport services, allowing the evaluation of equity in access and supporting the planning of improvements in urban mobility, which is essential for the connectivity and accessibility of residents in neighborhoods.

Finally, the indicator of the percentage of damaged infrastructure that was "rebuilt better" after a disaster is aligned with target 11.5 of SDG 11, which aims to significantly reduce the number of deaths and the number of people affected by disasters, including those related to water, and substantially decrease the economic losses, with a focus on protecting the poor and people in vulnerable situations. This indicator allows monitoring the resilience of housing and communities to extreme events, supporting reconstruction actions that prioritize infrastructure improvement and reducing the vulnerability of dwellings.

The indicators related to the percentage of green areas, present in the ISO 37.120 (ABNT, 2021), ISO 37.122 (ABNT, 2021), and ISO 37.123 (ABNT, 2021) standards, demonstrate a significant alignment with SDG 15, which addresses Life on Land (Table 04). These indicators provide crucial information about the availability and distribution of green spaces in cities, a fundamental aspect for the promotion of sustainable and healthy urban environments. They are directly aligned with targets 15.1 and 15.5 of SDG 15. The availability of green areas in the vicinity of housing is directly related to the quality of life of the population, providing benefits such as improved air quality, stress reduction, promotion of physical activity, and increased social interaction. Thus, these indicators are also aligned with the objectives of making cities more inclusive, safe, resilient, and sustainable, as advocated by SDG 11.

The indicators related to the crime rate, present in the three standards, demonstrate a significant alignment with SDG 16, which addresses Peace, Justice, and Strong Institutions (Table 04). These indicators provide essential information about public safety in cities, a fundamental aspect for the promotion of safe and inclusive urban environments. They are directly aligned with targets 16.1 and 16.2 of SDG 16.

Target 16.1 aims to "significantly reduce all forms of violence and related death rates everywhere" (UN, 2015). In this context, indicators on the crime rate are crucial for monitoring the evolution of violence and insecurity levels in cities, supporting the planning and implementation of public policies aimed at crime prevention and control. Target 16.2 seeks to "end abuse, exploitation, trafficking, and all forms of violence and torture against children" (UN, 2015). Although the indicators on the crime rate do not specifically refer to crimes against children, they provide relevant information about the

general level of safety in communities, including those where children reside.

Finally, the indicators related to the number of schools per 100,000 population, the unemployment rate, and the annual frequency of extreme events, present in the ISO 37.120 (ABNT, 2021) and ISO 37.123 (ABNT, 2021) standards, demonstrate a significant alignment with SDG 4, SDG 8, and SDG 13, respectively (Table 04).

The indicator of the number of schools per 100,000 population is directly aligned with target 4.1 of SDG 4, which aims to ensure universal and equitable access to quality primary and secondary education. The availability of schools in the vicinity of residential areas is essential to ensure access to quality basic education, contributing to the integral development of children and young people residing in these communities. The unemployment rate indicator is aligned with target 8.5 of SDG 8, which aims to achieve full and productive employment and decent work for all women and men, including young people and persons with disabilities, with equal pay for work of equal value. This indicator is essential for monitoring employment opportunities and the socioeconomic inclusion of the population residing in housing areas, supporting the adoption of public policies aimed at generating work and income.

Thus, the indicator on the annual frequency of extreme events, such as storms, heat waves, and cold waves, is aligned with target 13.1 of SDG 13, which aims to strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries. This indicator is essential for assessing the impacts of climate change on communities, especially in housing areas, supporting the adoption of adaptation and mitigation measures that increase the resilience of cities.

Table 4 - ISO Indicators Indirectly Related to Housing Aligned with the SDGs . Source: The Authors (2025).

ISO	ISO-Related Indicators Indirectly Linked to Housing	SDG
ISO 37.120 (ABNT, 2021)	Number of hospital beds per 100,000 inhabitants	Good Health and Well-being (3)
	Number of schools per 100,000 inhabitants	Quality Education (4)
	Unemployment rate	Decent Work and Economic Growth (8)
	Air quality	Sustainable Cities and Communities (11)
	Access to public transportation	Sustainable Cities and Communities (11)
	Percentage of green areas	Life on Land (15)
	Crime rate	Peace, Justice and Strong Institutions (16)
ISO 37.122 (ABNT, 2021)	Number of hospital beds per 100,000 inhabitants	Good Health and Well-being (3)
	Access to public transportation	Sustainable Cities and Communities (11)
	Percentage of green areas	Life on Land (15)
	Crime rate	Peace, Justice and Strong Institutions (16)
ISO 37.123 (ABNT, 2021)	Number of hospital beds per 100,000 inhabitants	Good Health and Well-being (3)
	Percentage of damaged infrastructure that was "built back better" after a disaster	Sustainable Cities and Communities (11)
	Access to public transportation	Sustainable Cities and Communities (11)
	Annual frequency of extreme events (storms, heat, cold)	Climate Action (13)
	Percentage of green areas	Life on Land (15)
	Crime rate	Peace, Justice and Strong Institutions (16)

The indicators from the ISO standards family related to housing demonstrate a significant alignment with various Sustainable Development Goals (SDGs), evidencing their relevance for monitoring and promoting sustainable development in cities.

The indicators linked to SDG 1 provide crucial information on the housing conditions of the population, including the availability of adequate and affordable housing, as well as the situation of homeless people. These indicators support the planning of public policies aimed at improving housing conditions and reducing poverty. Regarding SDG 11, the indicators related to housing and buildings address aspects such as the quality of constructions, vulnerability to natural disasters, and the adoption of sustainable practices in the construction industry. These indicators contribute to the promotion of more inclusive, safe, resilient, and sustainable cities.

Furthermore, the indicators aligned with SDG 6, SDG 7, and SDG 13 reflect the concern for efficiency in the use of resources, such as water and energy, as well as the vulnerability of housing to extreme weather events. These indicators support actions aimed at promoting environmental sustainability in cities. Other indicators, such as those related to education, employment, and public safety, also demonstrate alignment with SDG 4, SDG 8, and SDG 16, evidencing the breadth of the aspects covered by the indicators in the ISO standards family.

Therefore, the analysis of the alignment between the ISO indicators related to housing and the SDGs reveals the importance of these indicators for monitoring and promoting sustainable development in cities, supporting the planning and implementation of integrated public policies aimed at improving the quality of life of the population residing in these communities.

Alignment of Housing Indicators Based on Brazilian Standards and Regulations with the Sustainable Development Goals

This presents the results of the analysis of the alignment between the indicators based on NBR 15.575 (ABNT, 2021) and INI-R (Brazil, 2022) with the SDGs, seeking to understand how the criteria and requirements included in these regulations can contribute to the achievement of the goals established in the 2030 Agenda, and mainly in the development of more efficient and sustainable housing policies.

The criteria and requirements selected for analysis were considered as possible indicators, with the percentage of occupancy hours within a range of operative temperature, the maximum and minimum annual operative temperature, the air and impact sound insulation, the minimum levels of natural and artificial illuminance, demonstrating a significant alignment with SDG 3 on Health and Well-Being and SDG

11 on Sustainable Cities and Communities (Table 05).

Regarding SDG 3, these indicators are directly related. The thermal, acoustic, and lighting comfort of the dwellings is closely linked to the health and well-being of the residents, directly influencing their quality of life. Adequate indoor environments, with controlled temperature, lighting, and noise levels, contribute to the prevention of health problems, such as respiratory diseases, stress, and sleep disorders. With respect to SDG 11, indicators such as air and impact sound insulation contribute to the promotion of safer and healthier housing, while the requirements for natural and artificial illuminance aim to ensure the energy efficiency of buildings, reducing resource consumption and environmental impacts.

The indicator related to total thermal load demonstrates a strong alignment with SDG 7 on Affordable and Clean Energy (Table 05). By meeting performance requirements that minimize the total thermal load, the dwellings directly contribute to target 7.3 of SDG 7, which aims to double the global rate of improvement in energy efficiency. More energy-efficient buildings require fewer resources for air conditioning, reducing energy consumption and, consequently, the associated greenhouse gas emissions.

In addition, the reduction of the total thermal load in the dwellings also has a positive impact on target 7.1 of SDG 7, which seeks to ensure universal access to affordable, reliable, and modern energy services. By reducing the demand for energy for air conditioning, the dwellings become more financially accessible to the population, especially low-income families, contributing to the universalization of access to energy.

The analysis of the alignment between the housing indicators based on NBR 15.575 (ABNT, 2021) and INI-R (Brazil, 2022) with the SDGs demonstrates the relevance of these criteria and requirements for the promotion of sustainability in the housing sector. The indicators related to the thermal, acoustic, and lighting comfort of the dwellings, as well as energy efficiency, show a strong link with SDG 3 and SDG 11. These parameters play a fundamental role in ensuring the quality of life and well-being of the residents, contributing to the prevention of health problems and the construction of safe and healthy indoor environments.

The total thermal load indicator, aligned with SDG 7, demonstrates the importance of promoting energy efficiency in housing. By reducing the demand for energy for air conditioning, the buildings become more financially accessible, especially for low-income families, in addition to contributing to the reduction of greenhouse gas emissions. Therefore, the integration of these housing indicators into public policies and urban and housing planning instruments represents a fundamental strategy for the achievement of the Sustainable Development Goals, promoting the construction of more inclusive, resilient, and sustainable communities.

Conclusions

The research highlights the importance of housing in the context of sustainable development, emphasizing its fundamental role in mitigating climate change and promoting quality of life. The analysis of the indicators standardized by the ISO 37.120, ISO 37.122, and ISO 37.123 standards, together with the criteria of NBR 15.575 and the INI-R Normative Instruction, reveals a significant alignment with the Sustainable Development Goals established by the 2030 Agenda.

The results indicate that the housing-related indicators not only address issues of accessibility and adequacy of dwellings but also contribute to the promotion of more inclusive, safe, and resilient cities. The connection between housing conditions and the SDGs, especially SDG 1 and SDG 11, demonstrates that improving housing conditions is crucial for social and economic development.

Furthermore, the analysis of energy efficiency and environmental performance indicators, such as the criteria for thermal, acoustic, and lighting comfort, highlights the need for public policies that prioritize sustainability in buildings. The reduction of the thermal load and the adoption of smart metering technologies are essential to promote energy efficiency and accessibility, aligning with SDGs 6 and 7.

Finally, it is evident that the implementation of the analyzed standards and regulations can result in significant positive impacts on the quality of life of residents, in addition to contributing to the mitigation of climate change. The research emphasizes the need to integrate these indicators into housing policies, promoting sustainable urban development that meets the needs of the population and respects environmental limits. The continuity of studies on the intersection between housing and sustainable development is essential for the advancement of civil construction and urban planning practices in Brazil and worldwide.

Table 5 - Criteria and requirements of NBR 15.575 and INI-R aligned with the SDGs. Source: The Authors (2025)

ISO	Possible Indicators from NBR 15.575 (ABNT, 2021) and INI-R (Brazil, 2022)	SDG
Thermal, lighting, acoustic, and energy efficiency performance	Percentage of occupancy hours within an operative temperature range Temperatura operativa anual máxima Maximum annual operative temperature Minimum annual operative temperature Airborne sound insulation of external envelope systems Airborne sound insulation of floor and internal vertical envelope systems Impact sound insulation of floor systems Minimum levels of natural illuminance Daylight factor	Good Health and Well-being (3)
	Percentage of occupancy hours within an operative temperature range Temperatura operativa anual máxima Maximum annual operative temperature Minimum annual operative temperature Airborne sound insulation of external envelope systems Airborne sound insulation of floor and internal vertical envelope systems Impact sound insulation of floor systems Minimum levels of natural illuminance Daylight factor Total thermal load	Sustainable Cities and Communities (11)
	Total thermal load	Affordable and Clean Energy (7)

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