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Sustainability: concepts and application in architecture

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ABSTRACT

The work presents an analysis of the application of sustainability concepts to the architectural production of students at the School of Architecture and Urbanism at the Federal Fluminense University. The research investigates the consequences of the concept, listing eight principles and demonstrating them in practical project examples. The text also addressed how the bases and parameters were formed through dimensions and indicators; nevertheless, it describes the trajectory of sustainability in cities, in construction and architecture, complemented by the World Agendas. On the other hand, civil construction, being one of the largest energy consumers in the world, needs instruments for sustainable optimization and energy efficiency certifications prove to be a tangible means in the search for reducing the impact of the architecture sector, whether international ones such as the Building Research Institution Environmental Assessment Method (BREEAM) and Leadership in Energy and Environmental Design (LEED), as well as national ones, such as the Selo Procel Edifica. In the methodology, consultations in secondary sources stand out: books, articles and course completion work (TCC), the latter of which were extracted from a sample of eight TCC, representing 10% of the total guidance carried out over the most recent 20 years, which present the principles of sustainability more emphatically, specifically as references. The results describe the evolution of the concept through the proposals and how the inclusion of the topic in the Architecture and Urbanism Course triggers reflections, raises awareness among students and improves the quality of projects.

KEYWORDS: Architecture. Course Completion Work. Sustainability.

1 INTRODUCTION

The industrial revolution considered the amount of smoke emitted by industries a sign of progress and economic growth was pursued at any cost, without considering environmental and social issues. This view, however, was modified due to environmental management, until, in 1972, the Club of Rome report or Meadows Report was released, which dealt with crucial problems for the future development of humanity in terms of energy, pollution, sanitation, health, environment, technology and population growth. In 1987, the concept of sustainable development was published through the Brundtland Report, which defines as "[...] sustainable development is development that meets current needs without compromising the ability of future generations to meet their needs. own needs." (UNITED NATIONS, 1987, p.24).

However, for Acselrad (2009), the lack of precision in the concept of sustainability opens up the possibility of indiscriminate use of the word, generating mistrust and used according to the interest group. Confusion occurs when trying to answer: Is it possible to determine a balance between these dimensions of sustainability (environmental, economic and social) in city planning? And is the architecture being developed sustainably?

Despite the lack of objectivity of the concept that allows the word sustainability to be used without guaranteeing future performance, the word sustainability is always referred to in a positive way, mainly in the name of the preservation of natural resources. However, it is necessary that the gains are clearly disclosed and easily recognized so that the commitment to meet the needs of society and the preservation of natural resources continues to be pursued and valued, resulting in a cultural change, without the ills of social inequality, resulting from the economic model we live in.

In recent years, there has been a remarkable interest in sustainability issues in course conclusion work in architecture and urbanism. This interest reflects the growing concern with

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the preservation of the environment. It shows that despite the diffuse understanding of the meanings of sustainability, there is an awareness of students with a more sustainable and livable future for all.

2 OBJECTIVES

The general objective of this article is to reflect the impact of the concept of sustainability, highlighting eight principles and demonstrating their application in the production of Course Conclusion Work (TCC) by a group of students from the School of Architecture and Urbanism of the Federal Fluminense University (UFF). The specific objectives are: approach the formation of the bases for sustainability; explore the trajectory of sustainability in architecture and the World Agendas and expose architecture TCC through eight principles of sustainability.

3 METHODOLOGY

The methodology includes consulting secondary sources, such as books, articles and TCC, with a representative sample of eight TCC that emphasize the principles of sustainability. The eight TCC represent 10% of the total orientations carried out over the most recent 20 years, by one of the authors of this article.

4 THE BASIS FOR SUSTAINABILITY: EVOLUTION AND COMPLEXITY OF THE CONCEPT

The Industrial Revolution boosted the large-scale exploitation of natural resources due to technological advances and the optimization of the production line. This resulted in economic improvements, but it also caused environmental problems and social inequality. Awareness of environmental damage began in the 1960s and 1970s. In 1972, the first UN conference on the environment drew attention to environmental issues and pollution. In 1987, the Brundtland Report reinforced the importance of sustainable development and environmental preservation. The Eco-92 conference, held in 1992 in Rio de Janeiro, consolidated the concept of sustainable development and resulted in Agenda 21, a plan for building sustainable societies. In 2015, Sustainable Development Goals (SDGs) were established as part of the 2030 Agenda.

Sustainability is a complex notion and the term is often used interchangeably. The principle of evolution is highlighted by Acselrad (2009), which defines sustainability as not being a "concept" but a "notion". The concept is a scientific category and the notion is full of ambiguities and multiple contents. The fragility of the term, currently, when one sees the use of the word sustainability being used indiscriminately. Another issue comes from the use of the environmental preservation's concept as an excuse for segregation, removing communities from preservation areas and relocating them to distant regions, favoring the speculation.

Despite the limited growth of sustainable energy sources such as wind, solar and geothermal, global energy consumption is increasing. The large sustainability designs sector presents opportunities, provided there is careful planning and just transition policies. However, this sector is often undervalued or underutilized due to the influence of large polluting companies, which use ecological discourse or green marketing to increase production without

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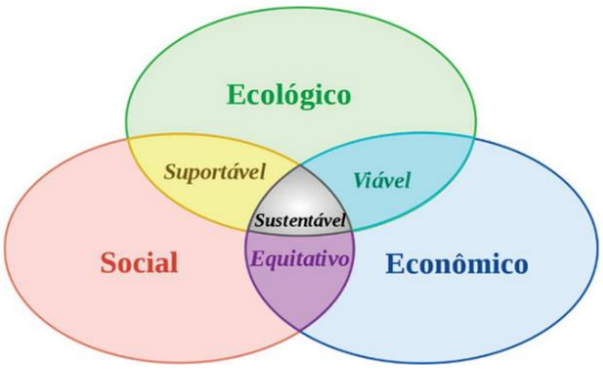
contributing to environmental preservation (DE PAULA; PENIDO, 2014).

For those who see the Agendas as an effective planning tool, the confusion around sustainability is evident in the disagreements between NGOs, governments, economists, environmentalists, sociologists, etc., about which dimension (economic, social or environmental) should be prioritized for sustainable development. Economists emphasize economic growth as a way to generate opportunities and jobs, valuing production and consumption to increase national wealth, often neglecting social and environmental aspects. On the other hand, environmentalists defend structural changes in production and consumption, adopting the perspective of "strong sustainability" and emphasizing the irreversibility of the environment and the importance of natural resources. Understanding the concept of sustainability, it is necessary to determine the relevant dimensions and indicators.

4.1 Sustainability parameters

In an effort to facilitate the understanding of the term sustainability, the British sociologist John Elkington, who graphically presented his concept in 1990, known as the Triple Bottom Line (People, Profit, Place). Which means that an action to be considered sustainable necessarily has to be ecologically correct, economically viable and socially fair. Figure 1 exemplifies it.

Figure 1 – Sustainability's tripod.



Source: Significados, 2011.

Sachs (1993) added the spatial and cultural dimension to the scheme defined by John Elkington, highlighting the importance of recognizing cultural differences and rural development. To be environmentally sound, any activity that causes negative environmental impacts must be avoided. This includes the reduction of gas and chemical product emissions, the improvement of waste treatment and use, the use of techniques for the use and recycling of water, the reduction of energy consumption and the development of materials with less impactful manufacturing processes and less energy consumption (LIMA, 2018). To be economically viable, sustainability requires that companies continue to generate profits, but in line with environmental preservation and social well-being. Sachs expands the criterion of corporate profitability, also considering aspects of a macroeconomic nature. In the social dimension, it seeks to value human rights, promoting actions with ethical bases, to provide social

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inclusion and outline strategies to reduce social inequality. With regard to cultural sustainability, Sachs (1993) presents the need for modern and environmentally sustainable processes that seek change within cultural continuity.

The Ecological Footprint and Biocapacity are indicators used to assess the human impact on the environment. The Ecological Footprint measures the demand for resources and the Earth's ability to regenerate, expressed in global hectares. It makes it possible to compare different consumption patterns and check whether they are within the planet's sustainable limits. Biocapacity is the ability of ecosystems to provide resources and absorb waste generated by human beings. Brazil has an important position on the world stage, being one of the largest ecological creditors on the planet (ALVES, 2012).

4.2 Trajectory of sustainability in architecture

Sustainability applied to the discourse of cities, according to Acselrad (2009) has three distinct representations: in the techno-material representation, the sustainable city seeks to minimize the consumption of fossil energy and natural resources, in addition to promoting the economy of recycling; in the representation of quality of life, it emphasizes the preservation of culture, heritage and beautification of the city, although it also mentions the negative impact of harmful emissions generated by urban technologies and in the representation of legitimation of urban policies, efficiency is measured by the ability to meet population.

In the architecture of the 20th century, Modern Architecture predominated, driven by the Industrial Revolution. This approach valued practicality over monumentality, using materials such as glass, concrete, marble and metals. The International Style of Modern Architecture moved away from regionalism and was not limited to available local resources. This aesthetic spread globally, with buildings based on metal structures and glass, abandoning construction techniques that took advantage of free natural resources. This resulted in higher energy consumption within buildings (ZAMBRANO, 2008).

In the Modernism, an architectural current emerged that sought harmony with the environment, led by Frank Lloyd Wright. He developed the idea of "Organic Architecture", which considered the work as a living organism, respecting nature and optimizing aspects such as lighting, ventilation and the natural environment. A famous example of this approach is Fallingwater house, built with reinforced concrete, stone, iron and glass, demonstrating that it was possible to design in the modernist style while maintaining harmony with the natural surroundings. In the 1970s, in response to the global energy crisis and concerns about the environmental damage caused by fossil fuels, Solar Architecture emerged. This approach sought to reduce or eliminate dependence on non-renewable energies, such as fossil fuels and nuclear energy, taking advantage of the potential of solar energy resources through the relationship with the local microclimate.

From the 1980s, Bioclimatic Architecture gained prominence, considering climatic conditions and using natural resources (sun, vegetation, rain and wind) to minimize environmental impacts and reduce energy consumption. There have been advances in the development of passive techniques and devices to protect or take advantage of the microclimate. In the late 1980s and 1990s, Ecological Architecture emerged, expanding the

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concept of sustainability in construction. In addition to integration with nature and the use of natural resources, it also valued aspects related to the environment throughout the life cycle of the building, considering impacts on global warming and climate change. At the turn of the 2000s, Sustainable Architecture emerged, covering not only environmental aspects, but also those related to Sustainable Development more broadly (economic, sociocultural, spatial and cultural). In addition to reviewing practices in relation to the environment, sustainable architecture considers the impact on people, cultures, social development, mobility and infrastructure in cities.

4.3 Sustainability of architecture on world agendas

The commitments, signed by UN member nations, present the world's knowledge of current problems and the priorities for trying to solve them. The Agendas make it possible for us to understand the problem of the current situation, which legitimized and made the sustainability objectives global, for the political reaction in the fulfillment of the established goals. In September 2015, the Commission for Sustainable Development presented the 2030 Agenda, a document resulting from a Global Partnership between the 193 countries of the UN, whose main objective is to end poverty and hunger in the world by 2030. 17 Sustainable Development Goals (SDGs) and 169 targets are set to achieve balance between the three dimensions of sustainable development: environmental, social and economic.

The Habitat Agenda is focused on sustainability in housing and urban development and the Habitat conference is held every twenty years. The first took place in 1976 in Vancouver, Canada. In 1996, the Habitat II conference was held in Istanbul, Turkey, with the theme "Adequate housing for all and the development of human settlements in an urbanizing world". The resulting document, the Habitat Agenda, presents guidelines for achieving sustainable development in all cities, with the goal of improving the standard of living of at least 100 million residents in precarious settlements around the world by the year 2020. In 2016, the Habitat III conference was held in Quito, Ecuador.

The Habitat Agenda contributed to the implementation of the 2030 Agenda for Sustainable Development in an integrated manner and to the achievement of the goals established for SDG11 - sustainable cities and communities, whose main goal is to make cities and human settlements inclusive, safe, resilient and sustainable.

The insertion of sustainable architecture is easily identified in SDG 11 - Sustainable Cities and Communities, but construction impacts not only this objective, but other objectives, that is, living in healthy buildings and inserted in the context of the city, influences health, well-being being, the eradication of poverty, the reduction of social inequalities, the management of water and energy resources, industry innovation, technological development and encourages national and international partnerships.

In order to understand the influence of sustainable architecture on other SDGs, in addition to Goal 11, one must consider the impacts of development for Goals 3, 7, 8, 9, 12, 13, 15 and 17: Goal 3 - Ensure a healthy living and promoting well-being for all at all ages; Goal 7 - Ensure reliable, sustainable, modern and affordable access to energy for all; Goal 8 - Promote sustained, inclusive and sustainable economic growth, full and productive employment, and decent work for all; Goal 9 - Build resilient infrastructure, promote inclusive and sustainable

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industrialization and foster innovation; Goal 10 - Reduce inequality within and between countries; Goal 12 - Ensure sustainable production and consumption patterns; Goal 13 - Take urgent action to combat climate change and its impacts; Goal 15 - Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation, and halt biodiversity loss and Goal 17 - Strengthen means of implementation and revitalize the global partnership for sustainable development.

4.4 Sustainability in design and interest in sustainable improvement

The construction sector has major challenges in the production of more sustainable buildings (SANTOS; CONTI, 2017). Sustainability in architectural design developed from the Agendas, providing reflections on a change of attitude and on creating buildings that are environmentally aware, socially responsible and economically viable. In addition, the processes to obtain a sustainable architecture transcend the mere durability of the structures, seeking to integrate a series of principles and practices that aim to reduce the environmental impact, promote a balanced relationship between humans and the natural environment and also involve consideration of aspects such as energy efficiency, use of sustainable materials and responsible water management.

Indeed, the energy efficiency of buildings is an important concern to promote sustainable building practices. To carry out a sustainability assessment in a building, it is common to resort to parameters and data provided by study boards and specialized organizations. These references facilitate and guide the designer on how to start the assessment and implement sustainability measures. The use of specific indices and parameters is fundamental for the analysis and evaluation of the energy performance of a building. They help rationalize energy use, ensure environmental comfort, as well as provide adequate thermal control. An integrated approach that considers these various aspects promotes efficient construction in line with the principles of sustainable development (ABREU, 2012).

With the growing interest in sustainability and energy efficiency in civil construction, research and classification systems have emerged to guide and regulate construction systems. These systems aim to award and evaluate consumption and energy efficiency in buildings. Currently, the two most widely used systems are the Building Research Establishment Environmental Assessment Method (BREEAM) and the Leadership in Energy and Environmental Design (LEED). These methodologies provide guidelines and criteria for evaluating various aspects related to sustainability, including energy efficiency, rational use of natural resources and internal environmental quality. They promote the adoption of sustainable practices and encourage the search for constructive solutions that are more responsible for the environment. In Brazil, the Selo Procel Edifica, developed by the National Electric Energy Conservation Program (Procel), has been adopted as an alternative way to prove the sustainable performance requirements of an architectural design (BUENO; ROSSIGNOLO, 2010).

Certifications assess the performance of buildings based on criteria. While energy efficiency and the use of renewable energy in architecture are important, they aren't enough to protect endangered resources. A cultural change in construction is necessary in pursuit of sustainability, following specific principles. Morão; Pedro (2009) identified nine principles of

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sustainable construction, including a global approach, rational land use, energy efficiency, water management, material and waste management, comfort in the use of buildings, adaptation to living styles, participation of inhabitants and flexibility of use. In this research, eight of these principles were selected, as the first refers to an integral approach and the study focuses on specific cases. The Course Completion Work (TCC) emphatically exemplify these principles and were guided by one of the authors of this article, representing 10% of the guidance given in the last 20 years.

4.4.1 Rational land use

The natural conditions of the land must be taken advantage of, adapting the design to the local topography, avoiding making radical changes, considering the largest possible area of permeable soil, seeking to use the lowest possible occupation rate allowed by law. The immediate surroundings must be considered, in order to favor the landscape, views and vegetation, promoting integration with the natural environment, origins and local culture, and not causing negative impacts on the neighborhood.

Figure 2 – TCC – Espaço Gaia

Source: Mello, 2018

The Espaço Gaia design, proposed for São Pedro da Serra, Nova Friburgo, in Rio de Janeiro State, was conceived for a rural property with a rational distribution of the needs program. The design includes the Casarão (headquarters), eight chalets for accommodation and a sauna chalet. The implementation of the design was adapted to the contours of the terrain, seeking a rational use of the available space and avoiding excessive unevenness. One of the premises of the design was to protect the soil from direct rain in the highest parts of the terrain, considering that the soil in the region is thin, preventing possible landslides. The insertion of plant species was planned that form a dense cover with fine roots, promoting better soil consolidation.

4.4.2 Energy and autonomy efficiency

For the rational use of energy inside the building, the architecture must employ bioclimatic design strategies, according to the climatic zones; use renewable sources for energy generation; maximize natural lighting; use artificial lighting systems and more efficient equipment.

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Figure 3 – TCC – Vale Shopping Cruzeiro

Source: Vianna, 2011.

The Vale Shopping Cruzeiro design aspired to value the land in the city of Cruzeiro, in São Paulo State. In the search for the energy efficiency of the building, resources were employed, such as the use of poles with solar receivers that allow the lighting of the parking lot, reducing dependence on the conventional electrical grid. In the same way, the internal lighting is powered by solar panels generating their own energy to illuminate the internal spaces, it was noted in this item the sizing calculation that resulted in about 205 panels with a capacity of 7.71A. In addition, the insertion of skylights at specific points and shafts for zenithal lighting allows the maximum use of natural light, reducing the need for artificial lighting during the day. The application of these resources helps to increase the energy autonomy of the building, making it more sustainable and efficient from an energy point of view.

4.4.3 Water cycle management

The amount of drinking water available is limited, and it is essential to think about the building with mechanisms that enable the rational use of this resource. Among the possibilities for using water from alternative sources to water from concessionaires are the use of rainwater, artesian wells and the reuse of gray water. In the planning phase, the maximum number of permeable areas for infiltration of rainwater into the soil must be considered in the project; installation of a water reuse and rainwater collection system; use of efficient equipment to save water and carry out adequate sewage treatment on site.

Figure 4 – TCC – Constructivist School: Santo Antônio School

Source: Morais, 2010.

In the Santo Antônio School design, for the city of Volta Redonda, in Rio de Janeiro State, specifics solutions were adopted to guide the sustainability process. One of the designs

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consists of collecting rainwater using cisterns, aiming to minimize the consumption of water resources for daily activities. In this way, there are sustainable impacts with the use of captured rainwater, reused for flushing toilets, cleaning and watering gardens, including benefits for urban infrastructure, which is often affected by heavy rains, with retention in cisterns.

4.4.4 Material and waste management

Material management must consider the use of raw materials that prioritize eco-efficiency and consider the circular economy throughout the production chain, which aims to maintain the circular flow of resources, prioritizing more durable, recyclable and renewable inputs. Materials must be used rationally and, whenever possible, regionally, avoiding costs and increased pollution resulting from the transport of materials. The reuse of buildings is the most efficient way to use resources, occupying empty buildings in places with infrastructure. In the case of renovation and retrofit, whenever possible, the use of existing structures and elements should be enhanced.

Figure 5 – TCC – Salinas Ferreira Inn and Restaurant

Source: Ferreira, 2014.

The Salinas Ferreira Inn and Restaurant design in Araruama, Rio de Janeiro State, mains steps seek to transform an unoccupied residential building through retrofit, thus conserving the historical heritage. The surveys were carried out to verify the existing materials, by calculating what would be demolished and their classification, mentioning the correct destination based on the current environmental resolution. A vegetable garden was also created for food production and the implementation of a composter to reduce waste and fertilize the garden, allocating organic waste produced daily to this location.

4.4.5 Comfort in the use of buildings

The design must promote comfort in the use of buildings, valuing air quality, good performance in the building in relation to acoustics, common use spaces for community integration, ease of access for pedestrians, accessibility, hygiene, stability, useful life of the

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construction, structural and fire safety. For comfort, it is necessary that: the main areas of occupation are located far from polluting sources; the building is designed to obtain satisfactory levels of thermal comfort, considering the use of bioclimatic zones and the incidence of solar radiation; natural ventilation is maximized; and valorization of natural elements in landscaping and the use of native species.

Figure 6 – TCC – Casa da Encosta

Source: Alves, 2014.

In the Casa da Encosta design, in the neighborhood of Itacoatiara, in Niterói, Rio de Janeiro State, a large single-family residence was considered, with the objective of creating a proposal that would satisfy all the needs and demands of the residents, following the principles of functionality, accessibility, environmental comfort, integration with the surroundings and nature, quality construction techniques, low waste and low environmental impact. A specific residence profile aimed at a specific public was chosen, recognizing the importance of meeting this type of demand. By identifying the residents' profile and needs, it was possible to define the different environments based on their functions and group them according to similarity and compatibility of use, generating integration between spaces. The concern with habitability was mentioned at various times and answered by the design proposals.

4.4.6 Adaptation to the ways of living

The adequacy of housing lies in the flexibility of space, materials and components in its designs, with the aim of considering the needs of users in the construction phase to avoid wasted materials, increased cost of work, increased waste, discomfort regarding noise, health problems, such as an allergic crisis, among other problems that a renovation can generate.

The Sustainable Residence design in Araruama, Rio de Janeiro State, demonstrates an adaptation of the ways of living through the interest in the elaboration of a well-defined program of needs together with the resident/investor and the application of several sustainable measures. The choice of location considered the proximity to services and urban areas, which contributes to the reduction of displacements and the use of existing infrastructure. The general objective of the design was to provide comfort to residents, reduce maintenance costs and promote the conscious use of natural resources, demonstrating a more sustainable housing model as possible.

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Figure 7 – TCC – Sustainable Residence in Araruama

Source: Ferreira, 2014.

4.4.7 Appropriation and participation of the inhabitants

The sustainability standards in the planning and construction phase, will only be perpetuated during the building's operation, if there is commitment and, mainly, a culture focused on valuing the environment and community participation. Therefore, it is necessary to promote user awareness, through environmental education, presenting the advantages of conscious use of energy, water, recycling of garbage, care for common areas of condominiums, vegetable gardens and other sustainable actions.

Figure 8 – TCC – Prototype for Eco-Sustainable Housing of Social Interest

Source: Silva, 2016.

The Social Interest Eco-Sustainable Housing design demonstrated an approach centered on the ownership and participation of the inhabitants, as well as on the environmental education of designers and residents. The location on the UFF university campus would allow for integration with the academic community and the creation of a learning environment. Environmental education for designers and inhabitants was a priority, aiming to disseminate sustainable practices and raise awareness about the importance of environmental preservation. The solutions adopted included rainwater harvesting to reduce potable water consumption, the use of solar and wind energy, the creation of an urban vegetable garden, space for composting

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and the planting of trees suitable for the local climate. The general objective was to promote sustainability and environmental comfort, meeting the needs of low-income families in an affordable way. In addition, the design sought to encourage student interest in sustainable processes in housing, involving them in the development and implementation of sustainable solutions.

4.4.8 Construction optimization and flexibility in use

The optimization and flexibility of the construction must consider the useful life of the building. In new designs, it is important to consider deconstruction, while in existing buildings, rehabilitation, retrofit and restoration are relevant. Deconstruction aims to increase the reuse of building elements, which are normally not damaged when disassembled. For this, it is necessary to specify removable connections, facilitate access to disassembly, use modularized parts and removable coverings, in addition to employing steel and wood constructive systems.

Figure 9 – TCC – Casa Brisa

Source: Sales, 2021.

The Casa Brisa design in Arraial do Cabo, Rio de Janeiro State, proposed a high standard single-family residential architecture, using concepts of critical regionalism, optimization of architectural resources and preservation of the region's natural characteristics. In the design, the integration of the internal environments with the external space was emphasized. Among the modular materials used, Cross-Laminated Timber (CLT) panels play an important role in construction, as they are versatile and allow the creation of buildings for different uses, in addition to allowing modifications when necessary. They can be combined with other building materials, such as metal and concrete structures, offering architectural design flexibility and freedom.

5 FINAL CONSIDERATIONS

The premise about sustainability, denotes that this is a complex and multifaceted concept, which involves environmental, social, economic and cultural dimensions, and should be used critically, observing the interests that express its use so that it is considered criteria of equity for fair development. The evolution of the concept of sustainability over time can be

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observed, from awareness of environmental damage to the adoption of policies and plans for building sustainable societies.

In architecture, sustainability also had a trajectory of development, going through different approaches, such as organic, solar, bioclimatic, ecological and sustainable architecture. Sustainable architecture plays an important role in the pursuit of the Sustainable Development Goals (SDGs), and this article inferred from SDG 11 the concept that best describes this proposal contributing to the creation of sustainable cities and communities and impacting other health-related goals, energy, economic growth, infrastructure, reducing inequality and partnerships.

The construction sector faces major challenges in the production of more sustainable buildings and requires a change of attitude to create environmentally conscious, socially responsible and economically viable buildings. Rating systems, such as BREEAM, LEED and Selo Procel Edifica, provide guidelines and criteria for assessing the sustainability of buildings. The adoption of sustainability principles such as rational use of the soil, energy efficiency and autonomy, water cycle management, materials and waste management, comfort in the use of buildings, adequacy to the ways of living, appropriation of the natural environment and participation of the inhabitants are fundamental to promote sustainable construction. The examples presented in the Course Completion Work (TCC) illustrate the application of these principles in specific architectural designs and show the interest of students in promoting designs that are in line with the reality in which we find ourselves, this position being very important, given that these will be the professionals who developed our cities in the 21st century.

REFERENCES

ABREU, W. G. **Manutenção Predial Sustentável**: diretrizes e práticas em shopping centers. Dissertação (Mestrado em Engenharia Civil). Universidade Federal Fluminense, Niterói, 2012.

ACSELRAD, Henri. **A Duração das Cidades**: sustentabilidade e risco nas políticas urbanas. 2. ed. Rio de Janeiro: Lamparina, 2009.

ACSELRAD, Henri. Discursos da sustentabilidade urbana. **Revista de Estudos Urbanos e Regionais**, n.79, 1999.

ALVES, Eustáquio Diniz. Pegada Ecológica e Biocapacidade. **Ecodebate**, edição nº 1.597, 23 may 2012. Available in: <https://rebrand.ly/1d8634> Access at: 05 may 2023.

ALVES, Thais C. de C. **Casa na Encosta**. TCC (Graduação Arquitetura e urbanismo). Escola de Arquitetura e Urbanismo, Universidade Federal Fluminense, Niterói, 2014.

BRASIL. **Agenda 21 Brasileira**: ações prioritárias. 2. ed. Ministério do Meio Ambiente, Brasília, 2004. Available in: <https://rebrand.ly/a742c9>. Access at: 02 maio 2021.

BUENO, Cristiane; ROSSIGNOLO, João Adriano. Desempenho ambiental de edificações: cenário atual e perspectivas dos sistemas de certificação. **Minerva**, v. 7, n. 1, p. 45-52, 2010.

DE PAULA, Igor R.; PENIDO, Marina de O. O desenvolvimento sustentável e as intencionalidades do discurso publicitário empresarial verde. In: I Simpósio Mineiro de Geografia, 26-30 mai. **Anais** [...]. Alfenas, 2014, p. 245-259.

ISSN 1980-0827 – Volume 19, Number 5, Year 2023

EMER, Aquélis Armiliato; CORONA, Hieda Maria Pagliosa. Percepção ambiental: uma ferramenta para discutir o ambiente urbano. **Revista ANAP Brasil**, n.7, 2013. Available in: <https://rebrand.ly/0c99fd>. Access at: 03 apr. 2023.

FERREIRA, Denise. **Residência Sustentável em Araruama**. TCC (Graduação Arquitetura e urbanismo). Escola de Arquitetura e Urbanismo, Universidade Federal Fluminense, Niterói, 2014.

FERREIRA, Patrícia. **Pousada e Restaurante Salinas Ferreira**. TCC (Graduação Arquitetura e urbanismo). Escola de Arquitetura e Urbanismo, Universidade Federal Fluminense, Niterói, 2014.

LIMA, Rosimeire Midori S. R. **Construções Sustentáveis**. Londrina: Editora e Distribuidora Educacional, 2018.

MACHADO, Maria Helena Ferreira. Urbanização e sustentabilidade ambiental: questões de territórios. **Revista de Estudos Urbanos e Regionais**, n. 3, p. 81-95, out. 2000.

MELLO, Victoria L. R. Z. de. **Espaço Gaia**. TCC (Graduação Arquitetura e urbanismo). Escola de Arquitetura e Urbanismo, Universidade Federal Fluminense, Niterói, 2018.

MORAIS, Vivian C. **Escola Construtivista**: Escola Santo Antônio. TCC (Graduação Arquitetura e urbanismo). Escola de Arquitetura e Urbanismo, Universidade Federal Fluminense, Niterói, 2010.

MOURÃO, Joana e PEDRO, João B. Para uma habitação ambientalmente mais sustentável (I): Recursos ambientais em risco. **Jornal Arquitecturas**, jun. 2009. Available in :<https://rebrand.ly/ba4db5>. Access at: 05 may 2023.

SACHS, Ignacy. **Estratégia de Transição para o Século XXI**: Para Pensar o Desenvolvimento Sustentável. Bulsztyn, Marcel (Org). São Paulo: Brasiliense, 1993.

SALES, Jhennifer F. **Casa Brisa**. TCC (Graduação Arquitetura e urbanismo). Escola de Arquitetura e Urbanismo, Universidade Federal Fluminense, Niterói, 2021.

SANTOS, Edson P.; CONTI, Thadeu das N.s. Mercado profissional para a área de energia e eficiência energética no Brasil. **Revista Internacional de Ciências**, v. 7, n. 2, Rio de Janeiro, 2017.

SIGNIFICADOS. Sustentabilidade, 2011. Available in: <www.significados.com.br/sustentabilidade> Access at: 19 may 2023.

SILVA, Liliane Rodrigues da. **Protótipo para Habitação Eco-sustentável de Interesse Social**. TCC (Graduação Arquitetura e urbanismo). Escola de Arquitetura e Urbanismo, Universidade Federal Fluminense, Niterói, 2016.

UNITED NATIONS (UN). Report of the world Commission on Environment and Development: note by the Secretary-General. [New York]: United Nations, 4 Aug. 1987. Available in: <https://digitallibrary.un.org/record/139811>. Access at: 15 may 2021.

VIANNA, Juliana R. **Vale Shopping Cruzeiro**. TCC (Graduação Arquitetura e urbanismo). Escola de Arquitetura e Urbanismo, Universidade Federal Fluminense, Niterói, 2011.

ZAMBRANO, L. M. A. **Integração dos Princípios da Sustentabilidade ao Projeto de Arquitetura**. Tese (Doutorado em Arquitetura e Urbanismo). PROARQ, Universidade Federal do Rio de Janeiro, Rio de Janeiro, 2008.