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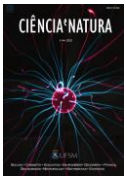

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Environment

A study on the triple bottom line concept applied to sustainable construction through the methodology of systematic literature review

Um estudo sobre o conceito do TBL aplicada a construção sustentável por meio da metodologia de revisão sistemática da literatura

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ABSTRACT

The concerns about construction sustainability, as seen by the Triple bottom line (TBL) framework, appeared in the 90's, as defined by Elkington. This concept aimed to provide a balance between the economic, social, and environmental dimensions. In order to consolidate the framework, it is important to identify the concepts related to sustainability that are being used in the context of sustainable construction. This paper performed a systematic review on the TBL concept applied to sustainable construction, from 2010 to 2021, in the following databases: Scielo, Scopus, and Science direct. Initially, 739 papers were found; 169 made it through the primary screening and 33 were selected after reading the abstracts and removing duplicates. An increase in TBL-related research was observed in the last 10 years, specifically in the field of sustainability of buildings. Likewise, new concepts have been incorporated, such as circular economy, which may result in new ways to support sustainable development. Many of the papers demonstrated the absence of a holistic view of evaluation.

Keywords: Sustainable construction; Sustainability; Triple bottom line

RESUMO

O início da preocupação com sustentabilidade na construção, por meio do conceito do Triple bottom line (TBL), surgiu na década de 90, cunhada por Elkington. Este movimento teve por finalidade proporcionar um equilíbrio entre as dimensões econômica, social e ambiental. Para consolidação do assunto, é importante identificar os conceitos relacionados à sustentabilidade que estão sendo utilizados no contexto na construção sustentável. O presente artigo realizou uma revisão sistêmica sobre o conceito de TBL aplicado à construção sustentável, no período de 2010 a 2021, nas seguintes bases de dados: Scielo, Scopus e Science direct. Foram encontrados, inicialmente 739 artigos, após filtragem 169 e após leitura dos resumos e retirada dos duplicados, restaram 33 artigos, que foram analisados, para dar

suporte a revisão. Evidenciou-se o crescimento da pesquisa na área TBL para a sustentabilidade das construções nos últimos 10 anos e que foram incorporados novos conceitos, como o de economia circular, que poderão desdobrar em novos caminhos para dar suporte ao desenvolvimento sustentável. Muito dos artigos demonstraram a ausência de uma visão holística de avaliação.

Palavras-chave: Construção sustentável; Sustentabilidade; Triple botton line

1 INTRODUCTION

The built environment and buildings have a great influence on the natural environment and quality of life. Buildings have always walked along with human history, and their purposes have not changed over time. However, with increasing urbanization, a greater collective concern regarding the use of natural resources has emerged in all industrial sectors (LAZAR *et al*, 2020).

In the construction industry, it was only in the 1990s that the concept of "sustainability" began to be incorporated into its actions and concerns, although it is considered an industry that exerts great pressure on the environment (TECHIO *et al*., 2016).

After the emergence of the need for sustainability in the construction industry, the concept of triple bottom line (TBL) was employed in the same period (the 1990s) by Elkington as a response to an alignment with sustainable development. The TBL was originally used to strengthen business financial plans by including environmental and social dimensions within the conventional model (GOH *et al*., 2020).

There is a common misconception of taking into consideration sustainability as only concerning environmental issues, without taking into account the interaction between the triple bottom line (TBL) formed by social, economic, and environmental dimensions (FIGUEIREDO *et al*., 2021).

Another factor that directly impacts construction sustainability is the choice of material, since the use of certain materials can drastically modify the footprint generated throughout the construction lifecycle (FIGUEIREDO *et al*., 2021).

Currently, there is great concern regarding the evaluation of sustainable systems. However, measuring these structures in a holistic way is challenging, as there is frequently a limited or distorted understanding of the dimensions that comprise sustainability (DURDYEV *et al*., 2018; ELKHAPERY *et al*., 2021; HAMMAD *et al*., 2019).

The purpose of this paper is to carry out a systemic review of sustainable construction and the concepts related to sustainability along with the TBL. Thus, we analyze current research trends and verify the use of the TBL for the construction sustainability.

The paper is structured in five sections, as follows: the first section explains the concept of sustainable construction and the concepts related to sustainability; the second section presents the relationship between sustainable construction and TBL; third section presents the methodology used in this papers and the systemic review; the fourth section presents the results; and the fifth and last section describes the conclusions.

2 MATERIALS AND METHODS

2.1 Sustainable construction and concepts related to sustainability

Sustainability is more than a sum of important questions. In a holistic view, it takes into consideration interconnections of a structure, including governmental actions, in a socio-ecological system (SILVA *et al*., 2018).

In civil construction, the term sustainable (or green) construction emerged to meet the demands of sustainability, being used by several authors as referring to efficient structures in terms of the use of resources (energy, water, and materials), but which require additional capital for their construction (ELKHAPERY *et al*., 2021).

While sustainable construction is more efficient in the long term than conventional construction, clients may avoid proposals that require additional

capital, particularly when the alternative project may have variable costs and benefits that are difficult to measure, as in the case of improved health and productivity (ELKHAPERY *et al*., 2021).

However, it is observed that sustainable construction initiatives lead to the effective implementation of economic investments, providing sustainable economic growth and the efficient use of resources (energy, water, and materials) (DURDYEV *et al*., 2018).

In the context of sustainable construction, there is some acceptance among scholars that the circular economy (CE) improves the lifecycle of components, materials, and products through reuse, repair, recycling, remanufacturing, and renovation (NOROUZI *et al*., 2021).

According to Silvestri *et al*. (2021), the concept of CE, which was developed from industrial ecology, aggregates several pre-existing ideas from various scientific fields with shared quality and characteristics.

According to Norouzi *et al*. (2021), the main areas of influence of the circular economy concept are the circular product design and the product lifecycle, including quality, economy, and integrated modular construction. However, CE has been addressed to a limited extent in construction-related research, as its application in this sector has a shorter history and was carried out on a smaller scale, being basically restricted to waste and materials management (with an emphasis on recycling).

Furthermore, there is still a lack of a practical approach towards circular economy, which could enable the integration of a holistic performance assessment tool with the circular business model for the construction industry (ANTWI-AFARI *et al*., 2021).

Another term introduced in 2002 at the Rio +10 conference was ‘sustainable consumption and production’ (SCP), which has as a initial consensus that the current patterns of extraction of natural resources, production, consumption, and

waste disposal are environmentally unsustainable and that measures must be taken to appropriately regulate consumption (PAGOTO *et al*., 2020).

According to Bamgbade *et al*. (2019), reducing ecological constraints is the key to sustainable business. The results of their study offer a more detailed explanation on how large construction companies can sustain these resources with the help of a friendly regulatory environment, that is, with regulatory measures for sustainable consumption.

Another terminology allied to sustainable construction is modular construction as an off-site production system in which a decision support tool is proposed to contrast conventional construction methods, being based on selected sustainability criteria (HAMMAD *et al*., 2019).

According to Cruz *et al* (2019), applying the concept of triple bottom line interconnected to sustainable buildings consolidates the commitment between economic sustainability (increasing the efficiency of work, materials, water, and energy, etc.); environmental sustainability (minimizing the impact on the environment and selecting materials carefully to protect the environment); and social sustainability (through participatory management, providing satisfaction to builders, employees, the local population, and everyone involved in the construction process).

Combining the tripod of sustainability with sustainable construction is one of the challenges for a holistic view related to this question. However, there is still a lack of clarity for this combination due to the difficulty of measuring the evaluation systems of the axes, especially of the social and environmental axes. Nevertheless, it is accepted that the holistic perspective derives from a multidimensional nature of the system in the built environment (CRUZ *et al*., 2019).

Sustainability concepts related to sustainable construction must be aligned to strengthen their relationship with the sustainability tripod and allow a holistic view. The next chapter addresses the relationship between sustainable construction and TBL.

2.2 Sustainable construction and TBL

In the mid-90s, John Elkington, was responsible for this concept. Initially, this terminology was aimed at answering economic questions, making an effort to include the environmental and social axes in the evaluation of traditional business performance, with an emphasis on finance (ELKINGTON, 1994).

According to Slaper and Hall (2011), the TBL is also known as the 3Ps, namely: people, planet, and profits, changinh the way of holistically measuring sustainability performance. However, the TBL does not have an evaluation method that can holistically measure the social, environmental, and economic axes of sustainability.

The challenge of accurately quantifying and evaluating all three dimensions of TBL, particularly the environmental and social dimensions, is notorious (SCHULZ and FLANIGAN, 2016). The gap in the evaluation standards of the three pillars of sustainability leads to the dissemination of imprecise solutions, which are somewhat obscure, as there is no concise holistic way of measuring them (HILL and BOWN, 1997).

On the other hand, sustainable dimensions seem to have received increasing attention from stakeholders committed to promoting such action. Kibert (1994b) introduced the term ‘sustainable construction’ at the First International Conference on Sustainable Building in Tampa, Florida, United States, meaning “[...] the responsible creation and management of a healthy built environment based on resource efficiency and ecological principles” (KILBERT, 1994a). Initially, the concept of sustainable construction was mostly linked only to environmental issues, later including issues regarding the economy and social sustainability (ABIDIN, 2009).

Sustainable construction must ensure integration between environmental, social, and economic sustainability in a balanced and ideal way, without one pillar standing out over the other. According to Cruz *et al*. (2019), applying the concept of triple bottom line interconnected to sustainable buildings consolidates the

commitment between economic sustainability (increasing the efficiency of work, materials, water, and energy, etc.); environmental sustainability (minimizing the impact on the environment and selecting materials carefully to protect the environment); and social sustainability (through participatory management, providing satisfaction to builders, employees, the local population, and everyone involved in the construction process).

According to Abidin (2010), social sustainability tends to receive less attention, while economic sustainability in construction refers to the financial gains of individual projects for the benefit of project stakeholders.

The TBL presents clear and better developed strategies and action plans for the construction industry, thus having the capacity to make a significant contribution to a sustainable future. The principles of TBL are practical and well-aligned with concepts related to sustainability in the construction sector (GOH *et al*., 2020).

However, the relationship between TBL and sustainable construction has not yet been detailed. This paper states that the TBL needs to be revised in order to allow a greater exploration of the subject for integration and improvement in the practice of sustainable construction.

2.3 Systematic Literature Review

To carry out the research, the systematic review method was used. This method of scientific investigation is based on a methodology used by medicine, consisting of a synthesis of the literature on the research topic in a comprehensive and impartial way (COOK *et al*., 1997; CHONG *et al*., 2017). To ensure an adequate understanding of the topic, the following scientific research databases were consulted: Scielo, Scopus, and Science Direct.

The papers surveyed covered the period from 2010 to 2021, in order to demonstrate the evolution of the topic of sustainable buildings. Scientific papers and review papers on the topic were considered for the review.

The main objective of the review was to analyze current research trends and verify the use of TBL for building sustainability. The Science Direct database search included the keywords 'sustainable construction', 'triple bottom line', 'sustainability', and 'and' in all fields and key terms. In the Scopus database, the keywords 'sustainable construction', 'triple bottom line', 'sustain*', 'sustainable development', 'green building', and 'and' were used in all fields and key terms. In the Scielo database, the keyword used was 'sustainable construction'. The Linguee website was used to translate the terms into English, as it shows the most recurrent words.

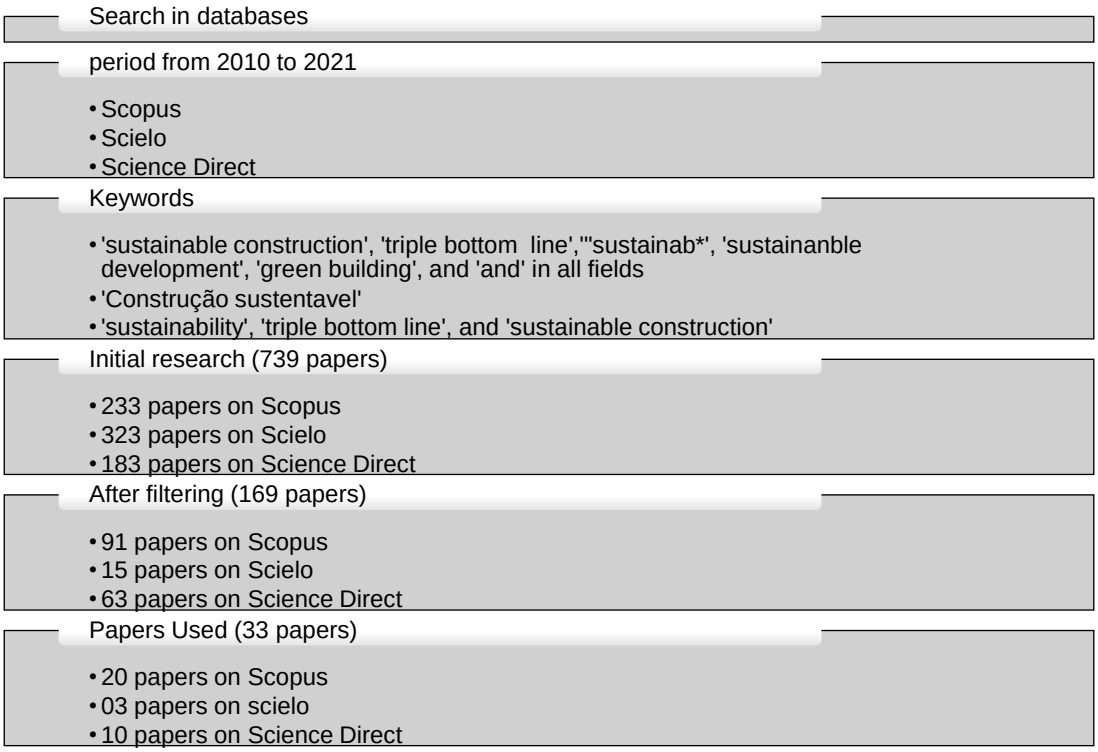
After defining the databases and keywords, the following exclusion criteria were created to direct the research: 1) papers that were not directly relevant to the topic of the study; 2) papers addressing only construction materials; 3) papers that only took into consideration sustainable substitutes for building materials/new technologies; 4) papers only analyzing building education; 5) papers only analyzing building risk and safety; and 6) papers written in languages other than English, Spanish, and Portuguese.

The next section presents the results obtained through the systemic review, obtained through the application of the research protocol described above.

3 RESULTS

From the research protocol used, thirty-three papers were used for the study, which were analyzed to investigate the concept of TBL applied to sustainable construction, as shown in Figure 1 below.

Figure 1 – Search protocol used in the databases

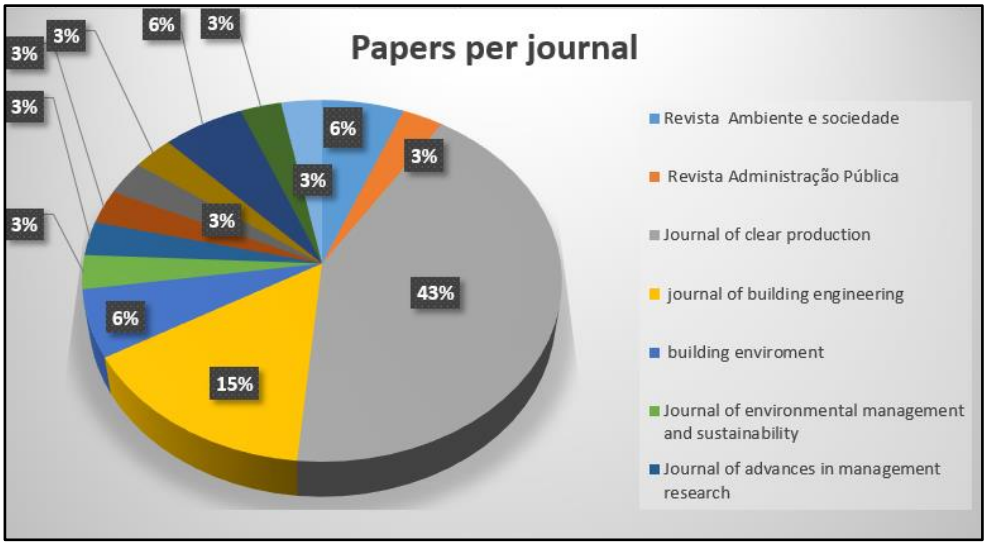


Source: Authors (2021)

Figure 1 shows the research protocol used, through which 323 papers were searched on Scielo, 183 on Science direct, and 233 on Scopus using the keywords aforementioned, totalling 739 relevant papers in the initial search of the databases. The papers were then filtered again by checking their content to determine overall relevance. This approach to filtering excluded a total of 570 papers, leaving only 169, which had their abstracts read, obtaining 38 papers. Subsequently, duplicate articles were removed, reaching 33 papers for the preparation of this study.

Regarding the development of research on Sustainable Construction and TBL and what are the future perspectives for the topic, it was verified that most of the researched papers (approximately 58%) are distributed between the *Journal of clear production* (14 papers) and the *Journal of building engineering* (five papers). These journals are international and have excellent diffusion in the academic environment, which reveals the impact of the research (Figure 2).

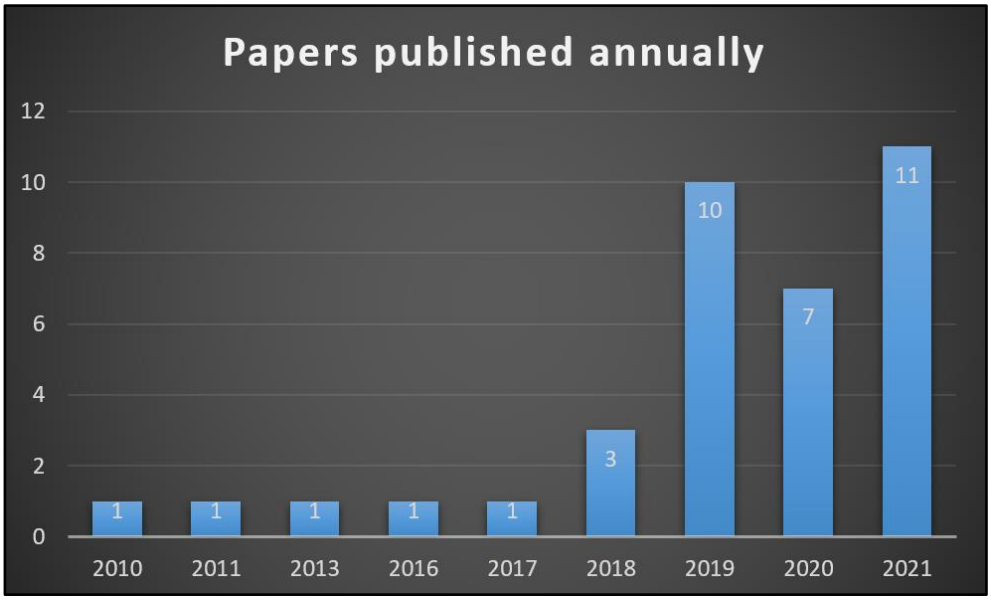
Figure 2 – Percentage of papers from each journal



Source: Authors (2021)

In a historical analysis, it is shown that between 2017 and 2021, the number of papers published on the topic increased, revealing a greater interest for research in this area, as shown in Figure 3.

Figure 3 – Graph showing the number of papers published per year



Source: Authors (2021)

Based on the 33 papers classified as relevant and of good quality for the study, which may contribute to the development of a foundation for the research, the cloud of the most cited words in their abstracts was built, as shown below.

Figure 4 – Cloud of most cited words in the abstracts of the selected publications

Source: Authors (2021)

Some observations that can be made in this cloud. Many publications focused on sustainability, sustainable dimensions, and evaluation systems. Another observation encompassing other papers besides the ones in the cloud is the large number of publications from China and India, revealing that these countries are carrying out a large volume of research in the areas of sustainable buildings and sustainability.

Several papers addressed the concepts of sustainability and the challenges faced by the construction industry to be sustainable, as out of the 33 papers surveyed, ten (10) papers addressed this topic (TECHIO *et al*., 2016; PAGOTO *et al*., 2020; GOH *et al*., 2020; SOLAIMANI *et al*., 2020; DURDYEV *et al*., 2018;

WIJESOORIYA *et al*., 2021; SHURRAB *et al*., 2019; CRUZ *et al*., 2019; CARVAJAL-ARANGO *et al*., 2019; RHEUDE *et al*., 2021).

Approximately four (04) papers proposed criteria and indices for sustainability, revealing some ways to measure sustainability (SILVA *et al*., 2018; STANITSAS *et al*., 2021; AGHILI *et al*., 2019; CHEN *et al*., 2010), while another three (03) papers related sustainable constructions with the circular economy, although their definition of the term was broad and all texts were published in 2021, demonstrating the relevance of the topic (ANTWI-AFARI *et al*., 2021; NOROUZI *et al*., 2021; SILVESTRI *et al*., 2021);

Regarding the sustainability evaluation system, sixteen (16) papers addressed the subject, although showing the absence of a holistic view of evaluation (DURDYEV *et al*., 2018; BAMGBADE *et al*., 2019; ELKHAPERY *et al*.; HAMMAD *et al*.; KAMALI *et al*., 2017; SIERRA-PÉREZ *et al*.; STANITSAS *et al*.; FIGUEIREDO *et al*.; FRANCO *et al*.; LAZAR *et al*.,2020; MATHIYAZHAGAN *et al*., 2019; ZARGHAMI *et al*., 2021; AKADIRI *et al*., 2013; FATOUREHCHI *et al*.; GOEL *et al*.; REZA *et al*., 2011).

These topics were also integrated into the triple bottom line, thus proposing a balance on the tripod (although barriers to application were identified especially in underdeveloped countries) and solutions to achieve sustainability in constructions in at least fifteen (15) papers (TECHIO *et al*., 2016; SILVA *et al*., 2018; BAMGBADE *et al*., 2019; DURDYEV *et al*., 2018; GOH *et al*., 2020; CHEN *et al*., 2010; REZA *et al*., 2011; LAZAR *et al*., 2020; MATHIYAZHAGAN *et al*., 2019; KAMALI *et al*.,2017; ZARGHAMI *et al*., 2021; STANITSAS *et al*., 2021; AKADIRI *et al*., 2013; CARVAJAL-ARANGO *et al*., 2019; WEN *et al*., 2020).

4 CONCLUSIONS

This paper consists of a review on the topic of sustainable construction linked to the triple bottom line, showing the research perspective and current conditions. There has been an increase in publications on the topic for the last ten years and new concepts have been incorporated, such as the circular economy, which may unfold new ways to support sustainable development.

For the implementation of the triple bottom line in sustainable construction, it is necessary that the three dimensions are in balance. However, barriers to the adoption of the TBL occurred specially in underdeveloped countries, such as Malaysia (DURDYEV *et al*., 2018).

It was evident that the use of TBL to improve building sustainability has increased in recent years, although evaluations in this area still present many weaknesses as they focus on only a few dimensions, not treating the topic in a holistic way. More research is needed in the area of dimension evaluation, with proposals for tools that can cover all dimensions and can be validated and replicated.

Despite the growth of research in the area, the concepts related to the dimensions of sustainability remained unchanged. However, there is a tendency to incorporate new perspectives through the circular economy.

It is important for steakholders to refine their knowledge of the principles of the TBL and its new perspectives, so that it can be effectively implemented in buildings, strengthening building sustainability.

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