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Review

Circularity as a Climate Change Mitigation Strategy in the Building Sector: The Stakeholder's Involvement in the Interconnected Life Cycle Phases

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Abstract: There is an evident relationship between climate change and the building sector through reciprocal environmental impacts. The circular economy is fitted into this relationship as a mitigation strategy in the building sector, thanks to its nature of life cycle perspective consideration, support for stakeholder collaboration, and the ideology of waste minimization, reduction of natural resource consumption, and greenhouse gas emissions. This article aims to conduct two subsequential systematic literature reviews to evaluate the status in the scientific literature about the circular economy as a climate change mitigation strategy in the building sector and to find the place taken in the scientific literature about the stakeholder's involvement toward circularity transition in the abovementioned link. As a result of the methodological approach, publicly available and reliable publications have been identified and analyzed based on the publication year and territory. The results indicate an increasing scientific literature contribution about the context, but the stakeholder concept is considerably taken less place; thus, it is a gap in the scientific literature. The stakeholder focal point, which the innovativeness of this article lays down, needs more attention in academic research, thus in the sector with the strengthening collaboration and mutual awareness among stakeholders.

Keywords: building sector; circular economy; climate change; stakeholders

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1. Introduction

Over 1000 years, climate change has always been a living fact on the Earth, and it refers to changes in temperature and weather patterns in the long term [1,2]. Nowadays, its impacts have demonstrated a dramatic increase and become more evident in the last decade of the 21st century. The leading causes of climate change have been associated with greenhouse gas emissions. However, starting with the industrial revolution, the distinct sources of them have shifted from natural sources like volcanic and seismic activities and fire disasters to anthropogenic human activities such as burning fossil fuels, deforestation, increase in livestock farming, application of nitrogenous fertilizers, and fluorinated gas production [3].

Greenhouse gas emissions due to these human-induced activities are namely: carbon dioxide, methane, nitrous oxide, and fluorinated gases (hydrofluorocarbons, sulfur hexafluoride, nitrogen trifluoride, perfluorocarbons). Their impact differs depending on their time in the atmosphere and their potential to trap heat. Among them, carbon dioxide presents the most significant share at around 82% [4]. Moreover, its concentration level in the atmosphere increased to 412 ppm in 2019, which was 280 ppm before the industrial revolution period, with a rising global rate of 20 ppm per decade since 2000 [5]. As emissions of greenhouse gases continue to rise and be emitted into the atmosphere, climate change and its consequences on humans and natural systems increase. The most well-known consequences on human and natural systems are the rising average global temperature (or so-called global warming), rising atmospheric carbon dioxide levels, and shifting weather (mainly rainfall) patterns. However, these principal consequences create successive consequences such as global ice sheets retreating, and consequent sea level rise, ocean acidification, floods, droughts, and heatwaves, as well as direct and indirect impacts on biodiversity, soil, agriculture, forestry, and human health [6–8].

The Earth's delicate balance between climate and life forms has been constantly changing due to the shifts in climate. The global average surface temperature (both air and sea surface) has risen 1.04 °C compared to the period before the industrial revolution [9]. The increased average global temperature due to global warming has been leading to the extreme and unpredictable weather conditions, frequency, and intensity of natural disasters, thus affecting human beings' capacity to respond effectively to climate change's consequences. World Meteorological Organization [WMO]'s comprehensive report [10] states that natural disasters associated with climate change have caused 2 million human life losses and 3.64 trillion US$ in economic losses. Moreover, the thermal expansion of the oceans due to global warming, and the melting of the land and sea ice sheets have caused an increase in the global mean sea level of 10.1 (±0.4) cm since 1993. About one-third of sea level rise has been accounted for by ice mass melting from the land ice sheets, recorded as 151 billion tons per year for Antarctica, while 273 billion tons per year for Greenland since 2002 [11]. If these rates of current climate change continue, global warming could reach 1.5 °C around 2040, and the consequences will have more severe impacts on the Earth [5].

Climate change has drawn attention at the intergovernmental level as an urgent and potentially irreversible threat to the sustainability of lifeforms on the Earth, and numerous acts for climate change have been performed to mitigate the consequences of it while adapting human beings' responses, behavior, and lifestyle to these consequences [12]. Starting with the establishment of the Intergovernmental Panel on Climate Change (IPCC) in 1988, there have been many milestones for international climate change combat, and the turning point among them has been achieved with the Paris Agreement, which the outcome of it was to limit global warming to well below 2 °C, preferably to 1.5 °C [1]. As a consequence of the Paris Agreement outcome, there has been an increasing number of national climate action pledges articulated by mainly developed countries, such as the European Union (EU), to cut greenhouse gas emissions, thus, mitigate climate change and adapt to climate change impacts through national-scale contributions. However, even though each country faces the effects of climate change on a local scale, it's a global issue regarding humankind, and the current national pledges are insufficient to achieve the designated goals of the Paris Agreement [13]. The reason is that global greenhouse gas emissions need to decline by 43% by 2030 and to net zero by 2050 to keep global warming below 2 °C and limit it to 1.5 °C [14].

On the way to achieve the Paris Agreement Goals, the driving forces behind climate change, thus emissions of greenhouse gases, need to be comprehended in detail at their sources in terms of sectors so that effective solutions for climate change can be found [15]. According to IPCC, the primary sectoral sources of greenhouse gases are namely: energy sector and transport (CRF1); industrial processes and product use (CRF2); agriculture (CRF3); land use, land use change and forestry (LULUCF) (CRF4); waste management (CRF5). The energy sector contributes almost 35% of the global and European direct greenhouse gas emissions, of which nearly 25% are the indirect emissions by electricity and heat generation in the energy sector [16]. Almost half of these indirect emissions are accounted to the building sector, whose global total share (direct and indirect emissions) climbs from 6% to 16% with the attribution of indirect emissions [13]. From both global and local perspectives, in other words, in the world and the EU, the building sector holds a significant share of indirect emissions due to heat and electricity production in energy-related emissions, which increases the building sector's total share to a considerably high amount. As a result, scientific and non-scientific interests have been addressed in the building sector's mitigation potential and potential to play a significant role in decarbonizing global and regional energy systems and meeting Paris Agreement Goals [17,18].

Many non-scientific research [5,13,14] addresses the building sector for climate change adaptation and mitigation. Still, this review article attempts to find the scientific literature's response to the path the non-scientific literature takes. The article aims to answer the following research questions: (1) How the building sector is addressed for climate change in the current scientific literature after the developments in the non-scientific one? (2) How the scientific literature proposes the circular economy as a strategy for climate change mitigation? and (3) What is the importance given by the scientific literature about the stakeholder's involvement toward the circular economy transition in the link between climate change and the building sector? This review article contributes two important issues' status development to the current scientific literature: the intersection of the circular economy, climate change, and the building sector, and the stakeholder's involvement in this intersectionality relationship. Therefore, after giving the concept, causes, and consequences of climate change, and its relationship with the building sector (Introduction), this article discusses the circular economy transition in the link between climate change and the building sector (The State of The Art). Followingly this article explains its methodological approach as a systematic literature review (Materials and Methods) and presents its results, discusses them (Results and Discussion), and finally, the article concludes its statement (Conclusions).

2. Literature Review

The building sector is classified under the construction sector, a part of the built environment. It is divided into two major processes: construction and operation, which is further divided depending on the operational types as residential and non-residential [19]. Starting with the industrial revolution, the building sector has been continuously growing and causing a significant increase in direct and indirect impact on the environment with mainly greenhouse gases emissions, which are divided into process-related emissions (direct emissions) and energy or operation-related emissions (indirect emissions), natural resource consumption and waste generation. Therefore, this sector is considered one of the significant contributors to climate change [20].

The building sector's energy demand and total global emissions have been increasing mainly due to energy-related emissions, while process-related emissions have shown limited growth [21,22]. From 1990 to 2019, the building sector's associated total emissions reached the peak level of 12 $GtCO_2$-eq., which was attributed to 38% of global total CO_2 emissions, whereas the associated final energy demand was 35% of the global energy demand [23]. After 2019, the trend in associated energy demand and CO_2 emissions have attributed respectively to 36% of global energy demand by decreasing 1% and 37% of global total CO_2 emissions by reducing almost 10% to a year before due to the COVID-19 pandemic situation [24]. However, in 2021, as expected, the reduction in energy demand and energy-related CO_2 emissions from the building sector have increased by 4% and 5%, respectively, from 2020 [24,25].

Considering the building sector's contribution to the past and current trends in global energy demand and global total greenhouse gas emissions, this sector has been considered a critical action toward climate change mitigation for the decarbonization of global and regional energy systems and meeting Paris Agreement Goals [14,26,27]. To decarbonize the building sector to achieve the Paris Agreement Goals, the targets of net-zero carbon for all new buildings by 2030 and the global building sector by 2050 should be satisfied [24,28,29]. With these targets, building process-related emissions (direct emissions) need to be decreased by 50%, and building energy-related emissions (indirect emissions) need to be declined by 60% by 2030 [30]. In other words, the building sector's total emissions should decrease by around 6% annually from 2020 to 2030 [23]. However, the Global ABC's Buildings Climate Tacker (BCT) system demonstrates that this sector's decarbonization is not on track to achieve the Paris Agreement Goals for 2030 and 2050 [24,25].

To ensure that national and global scale actions and policies towards decarbonization of the building sector to combat climate change, some of the authors from the current literature suggest that energy and climate change impacts of buildings should be understood in detail by identifying the environmental impacts through the life cycle perspective considering all the inputs and outputs due to each life cycle stage [31–34]. However, the approach to categorizing the environmental impacts related to the building life cycle is not single, and it changes from author to author in the literature. As an example, [35] classifies the environmental impacts of building activities: waste production, mud, dust, soil, and water contamination and damage to public drainage systems, destruction of plants, visual impact, noise, traffic increase, and parking space shortage and damage to public space, while [36] consider construction impacts under eight categories namely: soil and ground contamination, underground water contamination, construction, and demolition waste, noise and vibration, dust, hazardous emissions, and odors, wildlife and natural features impacts and archaeology impacts. Therefore, per the authors [31–34], this article considers four major environmental impacts associated with the building sector: natural resource consumption and depletion, waste production, environmental pollution, and climate change and global warming.

The building sector is a massive consumer of natural raw materials due to the extraction and manufacturing of non-renewable resources into building materials or components while consuming other resources such as water, electricity, or fuel. These processes eventually lead to natural resource scarcity and depletion. This sector is responsible for a large resource consumption of about 50% of all material extracted in the EU, and 20–50% of the consumption of natural resources in the world, particularly 50% of raw materials and products, 71% of electricity, and 16% of the water used [37,38]. The waste production over the life cycle of a building is contributed indirectly through the use of materials that have required the extraction of raw materials and manufacturing processes of them, while directly through the processes that construction materials undergo, the construction process itself, the use and maintenance of the constructed structure, and the demolition of the structure. Therefore, waste production in the building sector is accounted for more than 35% of the total EU waste [39], around 70% in the United States, 50% of the global solid waste, and 30–40% of the total waste in the world [40]. Environmental pollution is one of the major environmental impacts of the building sector affecting either local or global land, air, or water due to emitted pollutants from non-renewable energy production and consumption; raw material extraction, processing of raw materials; industrial processes; leaching toxic contaminants from waste disposed of in landfills, sewerage treatment plants and other waste disposal site [41]. Moreover, the building sector activities contribute a significant share in human-induced activities resulting in global warming and climate change due to the emissions of principally high amounts of greenhouse gases and pollutants in the life cycle. Considering the life cycle phases of a standard building, the main contributors to climate change, based on the life cycle assessment (LCA) metrics in terms of Global Warming Potential (GWP), come from the use phase for over 50% due to the high share on fossil fuel and electricity based energy consumption and energy-related greenhouse gases emissions, and followingly about 20–30% to climate change in the production phase, 5–10% for the construction phase, 8–10% for the end-of-life phase [42].

Therefore, climate change and its environmental impacts, such as shifts in temperature and natural events, affect the common style in the process and operation of buildings over the life cycle, whereas building's life cycle's common process and operation style, thus the environmental impacts, such as resource consumption, waste production, and greenhouse gas emissions, affect climate change by contributing it significantly. In other words, a strong and complex relationship exists between climate change and the building sector through reciprocal environmental impacts. In both ways of the relationship, the stakeholders must effectively play their role in their involved life cycle phases, from the production to the end-of-life phase [5,13,25,43]. The reason why is that the stakeholders have a significant role in the decision-making process for the design, construction, and operation of buildings, such as adaptation of the building sector to climate change (adaptation to shifted temperatures and natural events due to climate change), and the reduction of energy consumption and greenhouse gas emissions in building's life cycle phases for the decarbonization of the building sector, thus mitigation of climate change [13,25]. In other words, while buildings are aimed to be adapted to climate change's environmental impacts through adaptation measures, and climate change is aimed to be mitigated by the reduction in the building sector's environmental impacts through mitigation measures, the stakeholders play a significant role in this relationship (Figure 1).

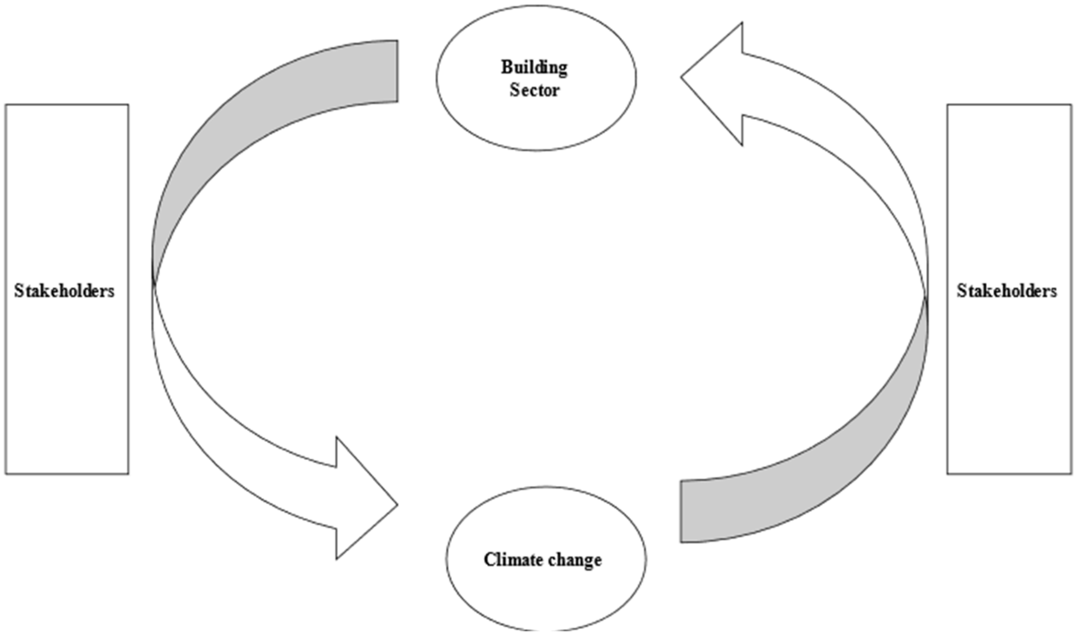

Figure 1. The relationship between climate change, and the building sector through environmental impacts, and the involvement of stakeholders in this relationship (Elaborated by the authors).

In the abovementioned relationship, there is a transition towards renewable energy and energy efficiency. However, a fundamental transformation in how goods are made and used is needed to meet climate change targets [44]. The reason is that the decarbonization of the energy systems is responsible for 55% of global greenhouse gas emissions. Still, the remaining 45% are directly linked to goods production and land management [45]. As a fundamental change in the global economy and its operating system in the link between climate change and the building sector, the circular economy has been embraced as a mitigation strategy against the problems of climate change in the building sector [46]. The reason why is that the circular economy's nature which is supported by the life cycle perspective and involvement of stakeholders towards decarbonization of the building sector to combat climate change, as well as its way of goods are made and used for both raw resource inputs and waste disposal which are the two highly carbon-intensive activities are closely linked with global warming [47–49]. Thanks to its approach powered by renewable energy to transform the way products are designed and used, the circular economy helps to achieve cuts in greenhouse gas emissions via three main principles; (1) elimination of waste and pollution to decline greenhouse gas emissions across value chains; (2) circulation of products and materials to retain embodied energy; (3) regeneration of nature to sequester carbon in the products, material, and soil [45]. The report states that the current global challenge of climate change can be tackled with a systematic transformation towards the circular economy and its abovementioned three principles and their strategies (Table 1). In other words, thanks to the circular economy perspective integrated into the building sector, as waste generation and resource consumption are reduced, greenhouse gas emissions consequently decline as a significant contribution to mitigating climate change (Figure 2). Adapting the circular economy can bring opportunities to tackle climate change by completing the rest of the way beyond the local and national climate pledges and policies, which currently deliver 15% of the way [50]. However, the report states that the current transition has only been completed globally by 8.6% resulting in a massive gap to be completed.

Table 1. Circular economy principles and strategies for climate change mitigation ([45] adopted by the authors).

Circular Economy Principle	Strategy	Goal
Elimination of waste and pollution to decline greenhouse gas emissions across value chains	Designing for circularity	Targeting the design phase for the integration of circular economy strategies like the design for disassembly, modularity, repairability, flexibility, etc., so that circulation of products, components, and materials are ensured.
	Eliminating waste	Declining the amount of material lost and waste generation during production thanks to design out waste.
	Substituting materials	Promoting circular materials instead of new production.
Circulation of products and materials to retain embodied energy	Reusing of products and components	Conserving products and components embodied energy and other valuable resources by keeping them in use to reduce the GHG emissions associated with new production and end-of-life treatment.
	Recycling of materials	Avoiding new virgin material production and end-of-life treatment by recirculation of materials while reducing greenhouse gas emissions
Regeneration of nature to sequester carbon in the products, material, and soil	Regenerative production	Managing agroecosystems that provide food and materials in ways that create positive outcomes for nature

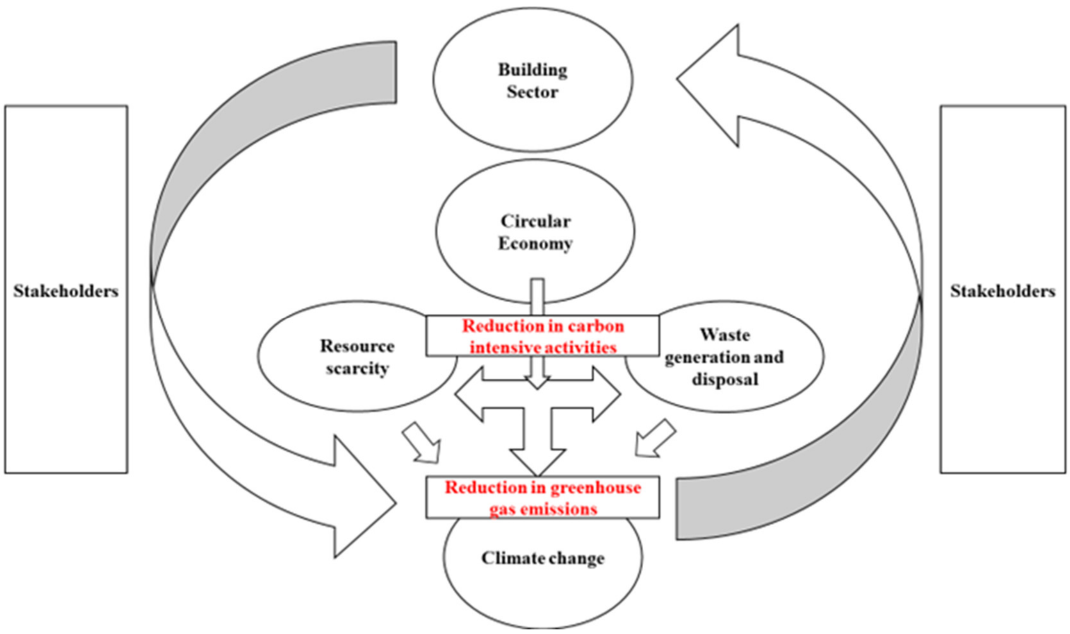

Figure 2. Circular economy introduction in the relationship between climate change, and the building sector through environmental impacts, and the involvement of stakeholders in this relationship (Elaborated by the authors).

Regarding the transition towards the circular economy, the building sector has been highlighted as a key area [51,52] that should act in one of the major roles in the circular economy transition [53,54], referring to it as one of the major responsible for climate change, due to the pressure created on the environment such as high energy consumption rate, solid waste generation, greenhouse gases emissions, and resource depletion. The importance of the building sector in the transition towards the circular economy comes not only from its contribution to the global economy [39,55] but also from its responsibility for the consumption of around 40% of the world's raw materials, which to be used in building's life cycle which is attributed to 41% of the global energy demand and is associated with 30% of global greenhouse gas emissions [23], and at the EU, its share of 38% of the total waste generation, 40% of the carbon dioxide emissions and 50% of all-natural resource's consumption [24].

Thanks to the abovementioned reasons, the circular economy has been gradually embraced in the building sector with two main sustainability targets: the reduction of environmental impacts and overall cost [56]. These targets are addressed in circular economy practice's different life cycle phases with the involvement of various stakeholders [57]. Currently, the circular economy practices in the building sector have three main focal point arguments; waste management and valorization [58,59]; reversible building design concept [60,61]; green deal within the building sector value chain, and business and stakeholder networks [62,63]. However, the current approach to the circular economy in the building sector still faces barriers blocking the proper conditions from stakeholders to integrate the circular economy in the building sector [64,65]. The barriers emerge from six main groups, namely: environmental, economic, social, organizational, technical, and regulatory barriers. Environmental barriers concern human health safety and risk due to the secondary use of building materials or system's possible toxic and contaminated content [66]. Economic barriers emerge from the high initial cost of investment and equipment, the lack of market and financial support from the government, and the high cost of secondary materials with respect to raw materials [56]. Social barriers are attributed to society; thus, they are related to the status quo and the lack of knowledge, trust, and interest in the circular economy [67]. The technical and technological issues of the secondary materials, such as low quality and poor reliability, as well as the lack of available data, are referred to as technical barriers [68]. The political barriers include the lack of standardization and legalization, such as standards, guidelines, recertification, and legal warranties [69]. Finally, organizational barriers are due to the complex and high-fragmented characteristics of the building sector in which different stakeholders work temporarily with only time, cost, and quality focused issues, rather than both short and long-term vision supported with strong and effective communication, collaboration for environmental impacts created due to the building process within the life cycle of a building and beyond [70,71]. Therefore, the circular economy implementation in the building sector for climate change mitigation should be ensured well with the reinforced collaboration and communication between the stakeholders within the life cycle of a building, from the design stage, through production, until the end of the life of a building [64,65].

Therefore, departing from the ideology of the circular economy implementation as a climate change mitigation strategy in the building sector, this article is oriented to evaluate the status development in the scientific literature regarding the circular economy transition in the link between climate change and the building sector and to find the place taken in the scientific literature about the stakeholder's involvement in the interconnected life cycle phases of buildings towards circularity in the abovementioned link. With this aim, the article conducts two sequential systematic literature reviews about the desired context.

3. Materials and Methods

The systematic literature reviews have been conducted on the Scopus database in which the review articles have addressed similar arguments related to the circular economy implementation in the built environment [46,72]. The flowchart (Figure 3) illustrates the various phases conducted in the two sequential systematic literature reviews. For both systematic literature reviews, only open-access scientific publications, which mean documents, posters, manuscripts, abstracts, or the like, of a scientific or medical nature, were considered. The open access restriction aimed to reach the completely available sources to the scientific community. Moreover, publications only in English were considered, and reference year limitation has not been introduced to determine when these desired sequential research arguments took their place in the scientific literature. For the first literature review, the methodological approach utilized the following search string: "circular economy" AND "climate change" AND "building sector." This methodological approach did not consider other keywords related to the circular economy (such as reuse, recycling, closed loop, industrial symbiosis, etc.) that relevant literature review articles [73–75] took place. The aim was to reach the publications that directly analyze the intersection between the abovementioned three keywords and to limit the literature review explicitly to the context of the ongoing and emerging research argument. For the second literature review, the methodological approach has utilized the following search string: "circular economy" AND "climate change" AND "building sector" AND "stakeholder." In other words, the previous search string has been narrowed down with the "stakeholder" keyword to further limit the research into the stakeholder's involvement in the context of the research argument.

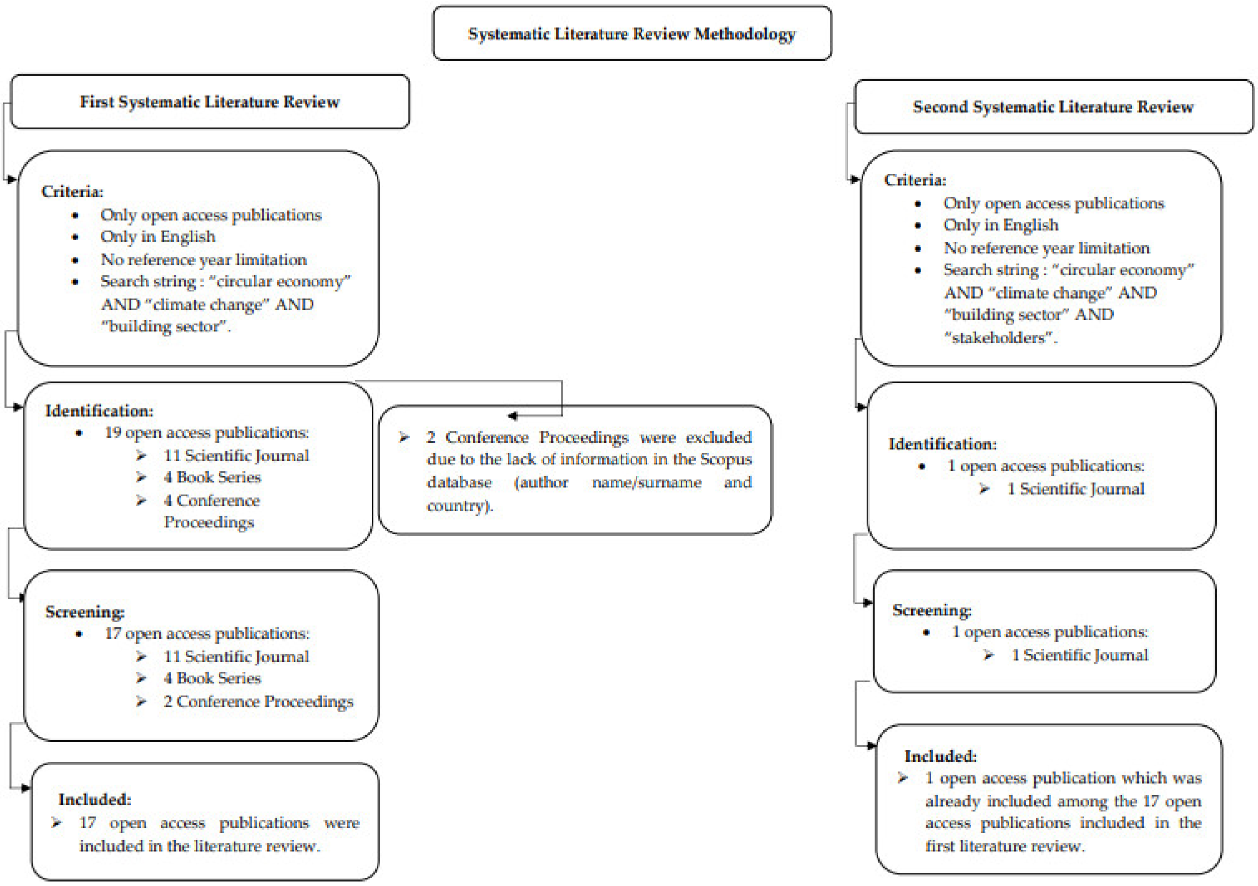

Figure 3. Flowchart of the methodological approach (Elaborated by the authors).

4. Results and Discussion

As a result of the first systematic literature review using the search string, 19 open access publications, of which 11 scientific articles, 4 book series, and 4 conference proceedings written in English, have been identified. 2 conference proceedings were not considered in the screening due to the lack of information regarding the author in the Scopus database. A total of 17 publications, as 11 scientific articles, 4 book series, and 2 conference proceedings, have been screened and included in the literature review. These publications were spread within a publication year reference range between 2013 to 2023 (Figure 4) and within a territory range from the EU countries to developing countries such as Thailand and Argentina (Figure 5). However, as a result of the second systematic literature review, only 1 publication [76], which was published in Finland in 2019, and already resulted among the 17 open-access publications of the first systematic literature review, has been identified, screened, and finally included in the literature review.

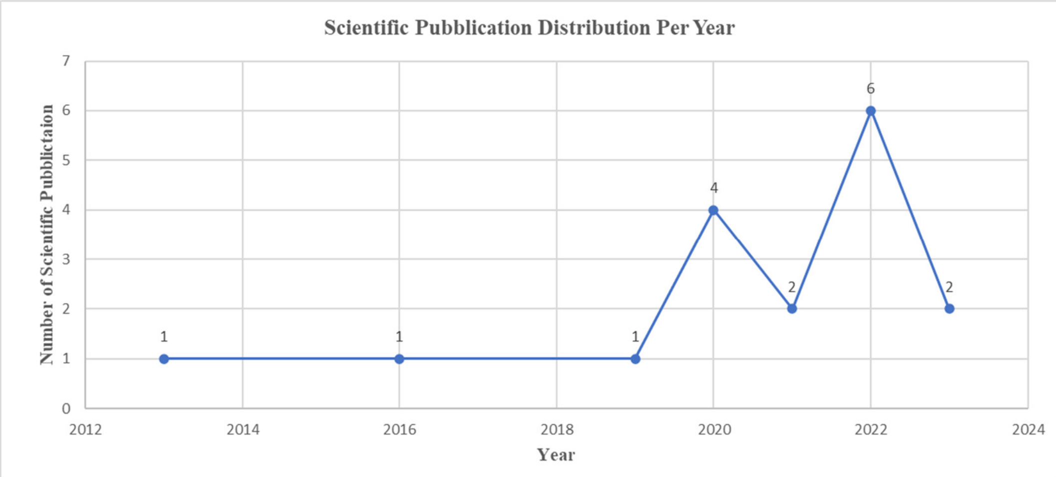

Figure 4. Scientific publication distribution per year (Elaborated by the authors).

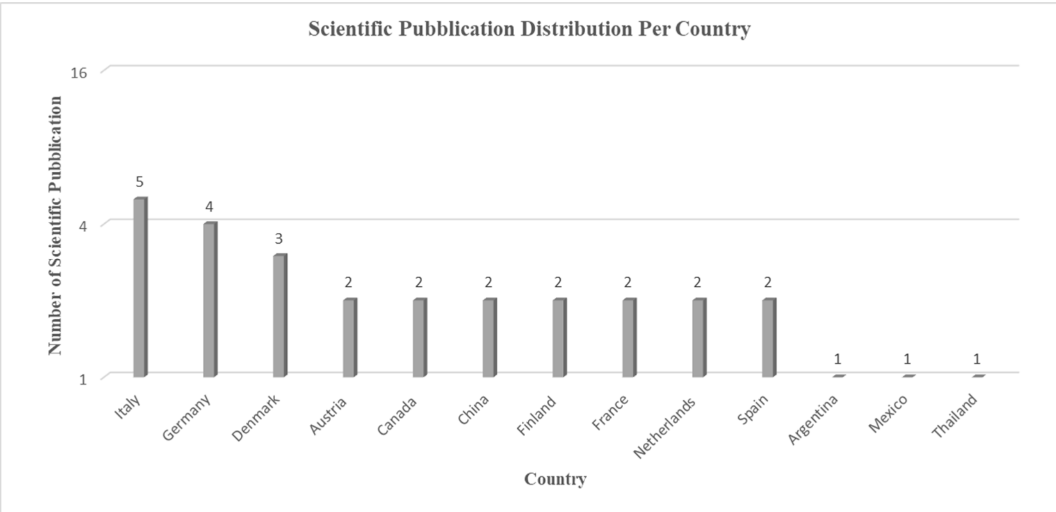

Figure 5. Scientific publication distribution per country (Elaborated by the authors).

All 17 scientific publications focus on the argument of the circular economy strategies for climate change mitigation in the building sector [77]; at the city level [78–80]; at the building level [76,81–87]; and at the material level [88–92]. All of them focus on the life cycle perspective to analyze the impacts of the building life cycle phases, but only [76] highlights the stakeholder's involvement in the life cycle phases.

The detailed content of these publications is as in the following. [77] analyze the concept of circular economy as a mitigation strategy within a sectoral analysis between industry, waste, energy, buildings, transport, and agriculture sectors by using a systematic literature review. [79] discuss the Chinese context between urbanization, climate change, interactions between infrastructure sectors, and the transformation of the building industry, and how policies implemented in the building sector orient the context. Similarly, from a policy point of view, [78] analyze the status quo and the policy developments in the building sector regarding greenhouse gas emissions and energy demand, climate impacts, and vulnerability, and design a model of resource use for material and water flow in Wuxi-the Chinese pilot city. Besides that, a policy perspective regarding the tax measures is discussed by [80] through a model construction evaluation of a large building sample for evaluating synthesis of the energy-environmental retrofit interventions in the historic building fabrics enhancement referring to general house-city-landscape system reform. Regarding the modeling of resource databases, [89] discuss the concept of construction and demolition waste with the integration of circular economy towards climate change mitigation on the Spanish and Mexican scale to broaden the construction material database and to add environmental indicators for "weighted transfer of measurement" current model, while [86] model a building material database for residential buildings to tackle global annual construction material demand scenarios and to estimate the availability of waste materials after building demolition towards 2050. Regarding the circular economy strategies for climate change mitigation on the building scale, [84] presents a narrative review of the net carbon zero buildings (NZCB), their definition, drivers, and barriers in the application to reach the target of zero operational and zero embodied carbon emissions, whereas [85] explains the current barriers of eco-design implementation in the building sector and how environmental issues in the design process by presenting a systematic literature review. [82] discuss the effective circular strategies to be applied for the target of net-zero carbon in the building sector by analyzing the reuse of an abandoned building in Milan as a case study by utilizing BIM and LCA, while [83] identify upstream and downstream strategies embraced in the architecture using several designated case-study buildings. [81] focus on urban mining as a circular economy strategy for climate change mitigation by assessing the concrete recycling scenario from the dismantling of the town hall building of the city of Korbach (Germany) to reusing again in the rebuilding process, and compares with the conventional concrete. At the same time, [76] discuss the importance of circular economy for Finland's climate change mitigation strategy in the building sector, highlighting the effective collaboration between building sector stakeholders toward the Finnish building sector's targets. Regarding the circular economy strategies for climate change mitigation on the material scale, [91] analyze the use of bio-based materials and circular building to close material cycles together with the material-related impact from 2018 to 2050 in the Netherlands, while [90] focus on the use of the different bio-based building products in France, and their possible volumes and waste deposits by 2050. [92] discusses the recovery of cannabis residual's application in the green building sector as a climate change mitigation strategy. On the other hand, some of the authors focus on conventional building materials such as [88], which discuss the potential benefit of wood reuse in terms of the environmental impact compared to traditional techniques by applying the statement to a case study building in Graz, Austria, whereas [87] discuss the circular economy strategy's effect on cement production and the associated emissions by using a bottom-up material flow modeling approach.

As can be observed from Figure 4, the scientific publication regarding the context starts in 2013, which coincides with the illustration of the circular economy concept as an industrial system that is regenerative by design, and as a business opportunity for economic and environmental opportunity by the Ellen MacArthur Foundation [44]. Followingly, the number of publications increases from 2013 to 2020, which meets the timeline of the European Union (EU)'s policy endorsements of the circular economy as an economic and policy strategy for the Sustainable Development Goals, the Paris Climate Agreement Goals, the ambitions of the European Green Deal and achieve carbon neutrality in Europe by 2050, and the designation of building sector as a key area for circularity transition [50,51,93]. Finally, the graph reaches its peak point in 2022, which coincides with the presentation of the circular economy as an opportunity to reduce greenhouse gas emissions by preserving the embodied energy of products and materials and increasing carbon sequestration through the regeneration of natural systems, thus as a major player by being a mitigation strategy to help tackle the climate crisis [45]. As the number of scientific publications about the context increases from 2013 to 2022, the number is expected to increase also in 2023 through the end of the year.

As can be observed from Figure 5, the scientific publication distribution is mainly in developed countries like China, Canada, the EU countries such as Italy, Germany, Denmark, France, and the Netherlands. There is increasing scientific research for decarbonizing the building sector through the circular economy in these developed countries, as the non-scientific research, such as policy frameworks and legislations at the governmental level, pushes and finances research in those countries [13,25]. Regarding the EU countries, throughout the past ten years in the EU, two circular economy policy frameworks and, consequently, a series of laws and regulations have been introduced to carry out the circular economy principles and strategies [50,51]. However, their articulation may demonstrate differences in each EU member states in which the EU policies and legislations are transposed and formed the base of national legislations and policies, thus the national circular economy policy frameworks. Besides that, even though the origins of the circular economy started in Europe, the circular economy-oriented policymaking could be traced back to China, where the non-scientific developments also oriented the scientific ones with them [94]. However, it can be seen in the figure that thanks to international awareness and the Paris Agreement and Sustainability Development Goals, developing countries such as Thailand, Mexico, and Argentina have started to work with research, effort, and dedication.

From 2013 to 2023, there is an increasing scientific interest in the literature in various countries, as the non-scientific interest in policy frameworks highlights the transition towards the circular economy and its potential as a climate mitigation strategy in the building sector. However, even though the importance of building sectors stakeholders is emphasized in the non-scientific literature, there is still much more effort and research needed in the context of the stakeholder collaboration and engagement in the life cycle phases toward the decarbonization of the building sector with the help of the circular economy to combat climate change. With the help of both scientific and non-scientific literature's collaboration, the current fragmented approach of the building sector, which does not enable stakeholders to communicate and collaborate toward the major aim of the decarbonization of this sector, can be changed with the help of the circular economy. Therefore, the stakeholder focal point on achieving the primary objective needs more attention in academic research, thus in the sector with the strengthening collaboration and mutual awareness among stakeholders who possess the environmental impacts created due to their activities along the life cycle phases.

5. Conclusions

Climate change has been affecting the sustainability of human well-being and biodiversity on the Earth through its environmental impacts, thus the common style in the process and operation of buildings in the life cycle. While building's life cycle's common process and operation style, hence the environmental impacts generated in the life cycle of a building, affect climate change due to its significant greenhouse gas emissions, natural resource (energy, water, and land) consumption, and waste generation. In both ways of this relationship, the stakeholders play an important role in the life cycle phases. Therefore, the circular economy is fitted into this complex relationship as a mitigation strategy in the building sector, thanks to its nature of life cycle perspective consideration, support for stakeholder collaboration and involvement, and the ideology of waste minimization, reduction of natural resource consumption, and thus greenhouse gas emissions.

This article conducts two sequential systematic literature reviews to evaluate the status in the scientific literature about the circular economy as a climate change mitigation strategy in the building sector and, specifically, the importance given by the scientific literature about the stakeholder's involvement in the interconnected life cycle phases of buildings. With these aims, the article has utilized a literature review methodology based on Scopus. As a result of the systematic literature reviews using the specific search strings, 17 open-access publications, 11 scientific articles, 4 book series, and 2 conference proceedings written in English were obtained for the first literature review. At the same time, the second literature review has resulted in only one publication which has also been obtained among the first literature review results. The publicly available and reliable publications are within a time reference range between 2013 to 2023 and within a territory-based distribution. The results indicate an increasing scientific literature contribution to the context. Still, the stakeholder concept is considerably less in the scientific literature and is a gap in the context that needs to be addressed and researched more.

The relationship between climate change and buildings in the interconnected life cycle phases should be approached as a whole-life system and systems-thinking approach instead of the current fragmented approach which prevents the collective action from decarbonizing the building sector, with the engagement of stakeholders to increase the support and chance of successful implementation of mitigation measures. The development of mitigation policies and broader sustainable development discussed and agreed upon with stakeholders will have a higher possibility of success. These targets and strategies towards zero-emission, efficient and resilient buildings, thus decarbonization, can be achieved with the engagement of stakeholders, which are aware of the environmental impact of their decisions across the life cycle of a building.

This article provides the scientific development achieved regarding the circular economy as a climate change mitigation strategy in the building sector and the importance of the building sector stakeholders between them. The focal point of the stakeholder concept brings the innovativeness of this article. However, for further research, the methodological approach can be developed to cover a broader range by including the other related keywords and other academic databases, which these issues are the limitations of this article.

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