

Analysis of Brazilian public policies related to the implementation of circular economy in civil construction

Análise das políticas públicas brasileiras relacionadas a implementação da economia circular na construção civil

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Abstract

Circular economy (CE) has been receiving increasing attention worldwide to increase the efficiency of the use of resources and minimize the generation of waste, aiming at a better balance and harmony between economy, environment, and society. It is an incipient concept, and its implementation is mainly associated with the support of public policies. Thus, the environmental and social impacts of the construction sector require alternatives to optimize the use of materials, encourage the recycling of construction waste (CW) and the correct disposal of non-reusable waste. This study aimed to analyze the Brazilian public policies that support the adoption of CE in the construction sector. It was possible to identify twelve public policies and their respective instruments, categorized into five guiding axes and according to the 9Rs framework of circular strategies. This study revealed that the adoption of CE is focused on reducing the CW, guided by normative instruments such as the National Policy for Solid Waste (NPSW), through the principles of shared responsibility and reverse logistics. The study contributes to the theoretical literature on public policies in support of CE and helps policymakers to create a circular policy plan to support the decision-making process in the construction industry and encourage the adoption of sustainable strategies.

Keywords: Circular economy. Construction waste. NPSW. Sustainable management.

Resumo

A economia circular (EC) vem recebendo cada vez mais atenção em todo o mundo como meio de aumentar a eficiência do uso de recursos, minimizar a geração de resíduos e melhorar o equilíbrio entre economia, meio ambiente e sociedade. É um conceito incipiente e sua implantação está associada, principalmente, ao suporte de políticas públicas. Dessa forma, os impactos ambientais e sociais do setor da construção civil necessitam de alternativas para otimizar o uso dos materiais, incentivar a reciclagem dos resíduos de construção civil (RCC) e a destinação correta dos resíduos não reutilizáveis. Este trabalho teve como objetivo analisar as políticas públicas brasileiras que apoiam a implantação da EC no setor da construção civil. Foi possível identificar doze políticas públicas e seus respectivos instrumentos, categorizados em cinco eixos norteadores e conforme a estrutura 9Rs de estratégias circulares. Este estudo revelou que a implantação da EC está focada na redução do RCC, norteada por instrumentos normativos como a Política Nacional de Resíduos Sólidos (PNRS), por meio dos princípios de responsabilidade compartilhada e logística reversa. O estudo contribui para a literatura sobre políticas públicas de apoio a EC e auxilia os formuladores de políticas na criação de um plano de políticas circulares para subsidiar a tomada de decisão e a adoção de estratégias sustentáveis na construção civil.

Palavras-chave: Economia circular. Resíduos de construção civil. PNRS. Gestão sustentável.

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Introduction

The construction sector represents 36% of the energy end-use and 39% of global carbon dioxide emissions, being a major target for environmental sustainability (INTERNATIONAL..., 2019). In addition, the sector is the world's largest consumer of raw material, generating up to 35% of urban landfill waste (GHAFFAR; BURMAN; BRAIMAH, 2020). In this sense, construction waste (CW) is a social challenge due to its growing volume and its associated environmental impacts, since in Brazil it represents more than 60% of collected urban solid waste (USW) in the cities (ASSOCIAÇÃO..., 2020). The large volume of CW is the result of the current linear economic model of “take-make-consume-dispose” (ELLEN..., 2015). The sector needs to implement strategies to reduce this problem and make a shift towards the adoption of sustainable practices (LIMA *et al.*, 2021).

Sustainability is a broad term encompassing triple bottom line aspects of – environmental conservation, social equality, and economic security. A gradual approach is required to achieve sustainability in the sector. The adoption of circular economy (CE) is a prerequisite to sustainability (GHAFFAR; BURMAN; BRAIMAH, 2020). CE offers an opportunity to reduce the use of primary materials and their associated environmental impacts, through different strategies that replace the end-of-life, such as reduction, reuse, and recycling of materials in the production/distribution processes and consumption (KIRCHHERR; REIKE; HEKKERT, 2017).

Several approaches, known as R-strategies, have been developed to achieve less resource use and material consumption in product chains. Value retention processes (VRPs) – also called R-imperatives – are key in realizing the cycles in CE (POTTING *et al.*, 2017). The three most principles of the CE concept are material reuse, reduce, and recycle (3Rs). Scholars have extended the concept to 6Rs, adding remanufacture, redesign, and recovery (KIRCHHERR; REIKE; HEKKERT, 2017). Potting *et al.* (2017) introduced more refuse, refurbish, and repurpose principles, creating a 9Rs framework (recover, recycle, repurpose, remanufactured, refurbish, repair, reuse, reduce, rethink, and refuse) ordered in a hierarchy from lowest to highest circularity.

These CE principles have gained academic, governmental, and organizational recognition. Globally, Japan and China were the first to introduce circular policies at the national level. In Europe, the CE has become a central aspect of policy and strategy development, and several countries have implemented initiatives, policies, and guidelines, like Germany, the Netherlands, and the United Kingdom (GUARNIERI; CERQUEIRA-STREIT; BATISTA, 2020). Directive 2008/98/EC is considered the European initial document on the implementation of the best waste management practices. In 2014, the European Union started the “Circular Economy Package”, with multiple action plans and legislative proposals focused on the industrials’ value chain. In 2020, the strategies were updated to a new Action Plan for the Circular Economy for a cleaner and more competitive Europe (EUROPEAN..., 2020).

Within the Brazilian Policy context, the main regulatory framework that approaches the circular economy principles is the National Policy for Solid Waste (NPSW), introduced in 2010 by Law No. 12305 (BRASIL, 2010). Brazil is considered the pioneer in Latin America and Caribbean countries to implement such legislation related to waste management (GUARNIERI; CERQUEIRA-STREIT; BATISTA, 2020). However, CE is not formally expressed in the national laws and has been approached in a decentralized manner in several public policies and focused on waste management. Despite the large political framework, the transition to implement CE in Brazil is incipient and the concept is still poorly understood.

Therefore, public institutions have an essential role in the development of a governance plan that combines an environmental and regenerative economy. Policymakers have the responsibility and conditions to enable the promotion of cultural changes through political instruments. It is important to develop a complete understanding of public policies that foster and hinder the transition to CE, from a social and economic perspective. This study seeks to analyze the main Brazilian public policies that support the implementation of CE in the construction sector. Through bibliographic and documentary research, the instruments of the public policies were categorized into five policy measures and according to the 9Rs framework of circular strategies. The study expands the discussion on the importance of circular public policies in the transition towards more sustainable buildings.

The 9R framework of circular strategies

The transition to CE is a solution to reduce environmental impacts and contribute to economic growth (GHAFFAR; BURMAN; BRAIMAH, 2020). CE acts as a regenerative system in which resources, energy,

emissions, and waste leakage are minimized by slowing, closing, and narrowing material and energy loops (BOCKEN *et al.*, 2016). A higher level of circularity of materials in product value chains means that smaller amounts of natural resources are needed to produce new materials (POTTING *et al.*, 2017). Then, the 9Rs framework, as shown in Figure 1, is an approach to implement circular actions in the building life cycle stages, maximizing the value of the materials and the energy recovery throughout production processes and consumption distribution flows in the construction sector.

Overview of generation and collection waste in Brazil

As noted by the 9Rs framework, CE seeks to recirculate resources and materials, and this involves the whole construction value chain. CE approaches waste management in a systemic way, planning and developing products whose waste is minimized or reused. In Brazil, the NPSW regulates both the management of solid urban waste (SUW) and CW, focused on the management of post-consumer waste. There are still few efforts and advances towards preventing the generation of waste and more circular consumptions and productions since the implementation of NPSW. Besides, waste management has deficiencies regarding the universalization of selective collection, the rates of recovery and recycling, and the final disposal of waste (ASSOCIAÇÃO..., 2020).

Figure 2 presents a history of the generation and collection of SUW and CW in Brazil. The data showed in Figure 2 are from the historical series of the Brazilian Association of Public Cleaning and Special Waste Companies (ABRELPE) from 2010, the initial milestone of the NPSW. The CW data refer to the collection carried out by the public service, which collects waste thrown in public places, as the responsibility for the collection and destination of this waste is generally of the generators.

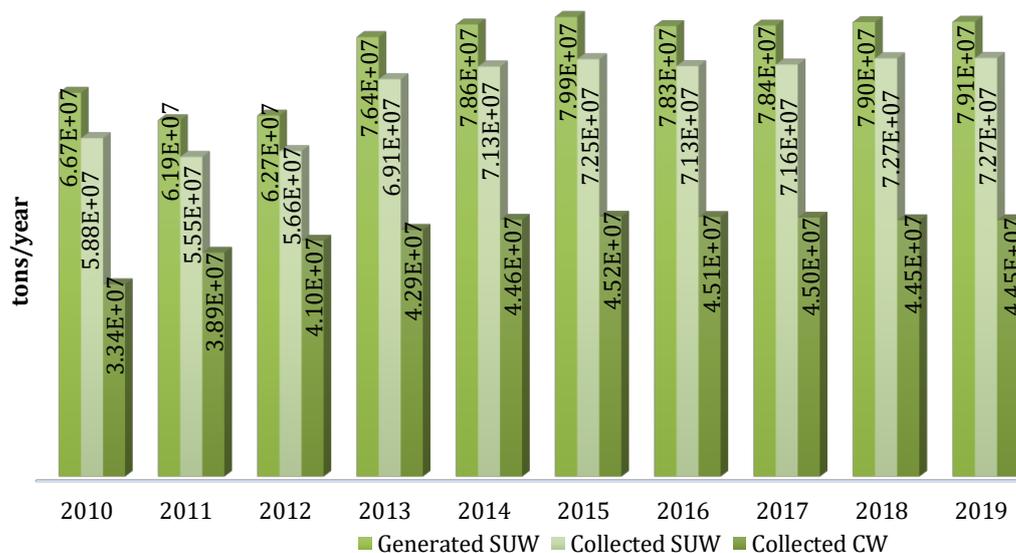
In 2019, more than 44 million tons of CW were collected in the country. Since 2010, the collected CW represents approximately 60% of the total mass of municipal SUW collected annually. According to Brasileiro and Matos (2015), more than 72% of Brazilian municipalities have a CW management service, however, only 7% of the municipalities have some type of waste processing and only 2.23% have CW reuse. To make it possible to recirculate materials, components, and parts of the buildings, waste must be perceived as a raw material for new products. Within this context, environmental legislation needs to be more effective, making waste generators responsible for the disposal of their waste and leading to the adoption of techniques to minimize waste and recycling policies (BRASILEIRO; MATOS, 2015).

Figure 1 - The circular 9Rs framework in order of priority

		Strategies	
		Strategy	Description
<p>Circular economy</p>	Smarter product use and manufacture	R0 Refuse	Make product redundant by abandoning its function or by offering the same function with a different product
		R1 Rethink	Make product use more intensive
		R2 Reduce	Increase efficiency in product manufacture or use by consuming fewer natural resources and materials
	Extend lifespan of product and its parts	R3 Reuse	Reuse by another consumer of discarded product which is still in good condition
		R4 Repair	Repair and maintenance of defective product so it can be used with its original function
		R5 Refurbish	Restore an old product and bring it up to date
		R6 Remanufacture	Use parts of a discarded product in a new product with the same function
		R7 Repurpose	Use a discarded product or its parts in a new product with a different function
	Useful application of materials	R8 Recycle	Process materials to obtain the same or lower quality
R9 Recover		Incineration of material with energy recovery	
Linear economy			

Source: adapted from Potting *et al.* (2017).

Figure 2 - History of the generation and collection of SUW and CW in Brazil



Source: annually ABRELPE reports (ASSOCIAÇÃO..., 2020).

Public policies for the circular transition

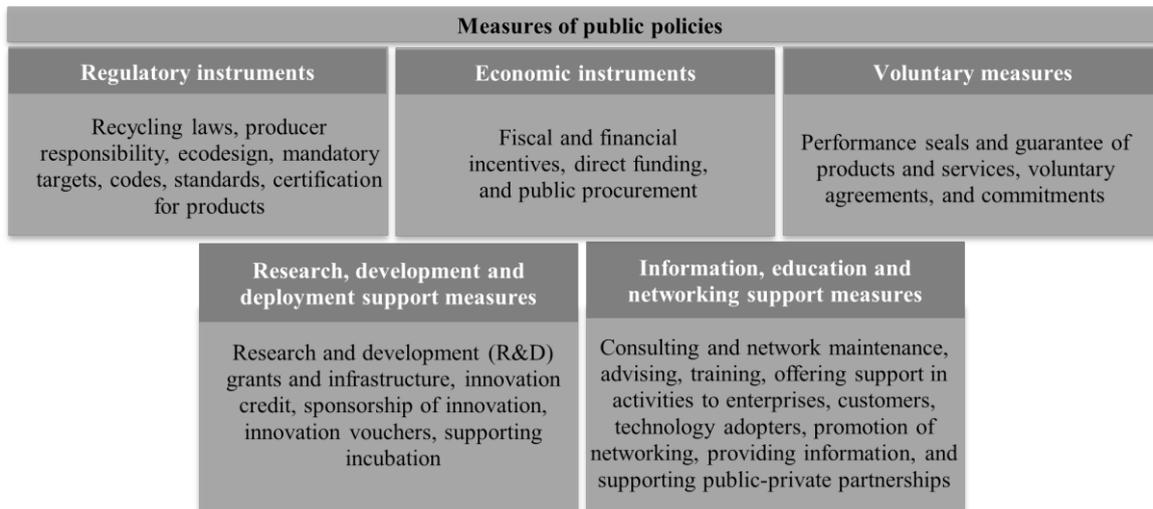
The intensification of social, economic, and environmental problems related to CW led governments to strengthen efforts to solve these problems. At the macro level, the CE implementation is the result of public policies and the performance of other agents, such as foundations and business development agencies (POMPONI; MONCASTER, 2017). To Secchi (2019) public policies are guidelines for political decisions aimed at facing a public problem. The public power has a decisive role in guiding the CW management, using instruments of regulation, inspection, and creation of conditions for the environmentally correct treatment. For Doranova *et al.* (2016) national and local governments can implement five axes of policy measures to promote CE initiatives, as shown in Figure 3.

Public policies are fundamental as inducers of changes that, through instruments and public sector leaders, can encourage circular behaviors and actions. The five axes of policy measures, shown in Figure 3, have different focuses of action, but they all converge towards the purpose of establishing a sustainable policy plan. For example, the regulatory instruments deal with the elaboration and promotion of legislative acts that support activities and changes. Economic instruments influence organizations' financial and budgetary issues, representing benefits or inducing the search for alternatives. Voluntary measures reflect people's engagement in the participation and transformation of their societies. Finally, the axes of research, development and deployment support and information, education and networking measures are essential to promote social values, knowledge, skills, attitudes, and competencies essential to the quality of life and sustainability.

Research strategy

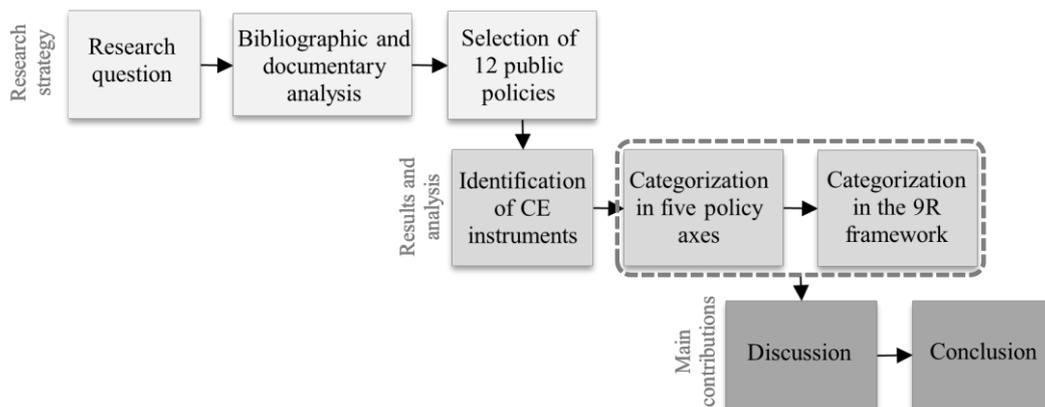
The study sought to answer the following question: which are the Brazilian public policies that relate to the implementation of the CE in the construction sector? The research approach was based on bibliographic and documentary analysis of the main national public policies. The study considers ordinary laws and normative resolutions that make up the Brazilian legislative framework. The identification of the public policies considered the environmental and sustainable consumption legal and institutional framework established by the Action Plan for Sustainable Production and Consumption (PSPC) (MINISTÉRIO..., 2014). Twelve documents were identified and analyzed, and their instruments were two-fold categorized. Figure 4 summarized the research strategy adopted.

Figure 3 - Range of policy measures



Source: adapted from Doranova *et al.* (2016).

Figure 4 - Summary of the research strategy of the study



Results and analysis

Table 1 presents the main national public policies related to the implementation of the CE in the construction sector. The main instruments concerning each public policy related to the CE were described below.

Law No. 9.795 (BRASIL, 1999) establishes the National Policy for Environmental Education for the qualification and training of educators at all levels and modalities of society. It considers environmental education as a primary factor for the implementation of sustainability in the means of social production and consumption (BRASIL, 1999). The law argues that the government must establish policies that promote education and assume the commitment of society in the conservation, recovery, and improvement of the environment.

Law No. 10.257 (BRASIL, 2001) instituted the City Statute and can be considered a pioneer in the creation of legislation on CW management. Based on this law, the need for the disposal and treatment of construction and demolition waste generated was legally established, as previously, the legislation was limited to prohibiting its disposal on public roads or public places. Thus, waste began to attract society's attention in urban planning and the law-instituted rules that intended to regulate the occupation and use of urban land. The guidelines provide for the guarantee of the right to sustainable cities, understood as the right to urban land, housing, and basic sanitation (BRASIL, 2001).

Table 1 - Brazilian public policies relating to CE in the construction sector

	Public policy	Year	Title	Aim
Federal Laws	Law 9.795	1999	National Environmental Education Policy	The development of an integrated understanding of the environment
	Law 10.257	2001	General urban policy guidelines	The development of the social functions of the city and the urban property
	Law 11.445	2007	National basic sanitation guidelines	To establish national guidelines for basic sanitation and the federal basic sanitation policy
	Law 12.187	2009	National Policy on Climate Change (NPCM)	Sustainable development to face climate change and meet the needs of populations
	Law 12.305	2010	National Solid Waste Policy (NSWP)	Integrated and environmentally sound management of solid waste
	Law 14.026	2020	Updates the legal framework for basic sanitation	Updates the legal framework of the basic sanitation system
Resolutions	Resolution No. 307	2002	CONAMA Resolution No. 307, July 5, 2002	To establish guidelines, criteria, and procedures for the management of construction waste
	Resolution No. 348	2004	CONAMA Resolution No. 348, 16 August 2004	To include asbestos in the hazardous waste class
	Resolution No. 431	2011	CONAMA Resolution No. 431, May 24, 2011	To establish a new classification for plaster as belonging to class B
	Resolution No. 448	2012	CONAMA Resolution No. 448, January 18, 2012	To update some requirements of Resolution No. 307
	Resolution No. 469	2015	CONAMA Resolution No. 469, July 29, 2015	To update some requirements of Resolution No. 307
Plan	Action Plan	2011	Action plan for sustainable production and consumption (MINISTÉRIO..., 2014)	To encourage dynamics and actions that contribute to the sustainable development of Brazilian society

In addition, the City Statute addresses guidelines for the ordering and control of land use to prevent the misuse of urban properties, the underutilization or non-use of properties, pollution, and environmental degradation. It cites legal and political instruments provided for in civil law, such as expropriation, adverse possession of the urban property, installations, buildings, listing, and land tenure regularization. Furthermore, national, regional, and state plans for territorial ordering and social-economic development are established; tax and financial institutes; in addition to the Environmental Impact Study (EIS) and Neighborhood Impact Study (NIS) in the implementation of housing projects (BRASIL, 2001). One of the most important instruments of the law is the Master Plan as a basic instrument of urban development and expansion policy.

Law 11.445 (BRASIL, 2007) establishes national guidelines for basic sanitation, considering a set of services for the public supply of drinking water; collection, treatment, and final disposal of sanitary sewage; drainage and management of urban rainwater, as well to urban cleaning and solid waste management (BRASIL, 2007). Urban cleaning and solid waste management are comprised of waste collection, transshipment, and transportation activities; sorting for reuse or recycling purposes; treatment, including composting, and waste final disposal. It also refers to the waste originating from sweeping, weeding, and pruning trees on roads and public places and other urban public cleaning services. The law also prioritizes the universalization of services, the reduction, and control of water losses, encouraging the rationalization of its consumption by users and promoting energy efficiency, the reuse of sanitary effluents, and the use of rainwater (BRASIL, 2007).

The institution of the National Policy on Climate Change (NPCC), created by Law 12.187 (BRASIL, 2009), represented an important milestone in the regulation of climate protection at the national level. The NPCC encourages the adoption of activities and technologies with low emissions of greenhouse gases (GHG), and sustainable production and consumption patterns (BRASIL, 2009). The law establishes sectoral plans to meet gradual targets for reducing quantifiable and verifiable anthropogenic emissions considering sectors

such as public transport and the construction industry. Although, it is still in the implementation phase and the protagonism of the State must merge all sectors of society for its effective implementation.

In 2010, Brazil passed Law 12.305 (BRASIL, 2010), which instituted the National Policy for Solid Waste (NPSW). NPSW establishes principles, objectives, instruments, and guidelines for the management of solid waste, the responsibilities of generators, public authorities, and consumers, as well as the applicable economic instruments. The law covers and correlates important principles such as prevention and precaution, polluter-pays, eco-efficiency, shared responsibility for the product's life cycle, recognition of waste as an economic and social value asset, and the right to information (BRASIL, 2010).

The NPSW encourages the development of environmental and business management systems aimed at improving production processes and the reuse of solid waste, including recovery and energy use. The Policy establishes as its main objective the non-generation, reduction, reuse, recycling, and treatment of solid waste, as well as the environmentally appropriate destination of the waste (BRASIL, 2010). This goal is reinforced by the institution of the shared responsibility for the product's life cycle, covering manufacturers, importers, distributors, traders, consumers, and owners of public services for urban cleaning and solid waste management.

In article 33, the NPSW establishes the system of reverse logistics, articulated with the selective collection, for the implementation of shared responsibility (BRASIL, 2010). This system is one of the main milestones of the law and aims to enable the collection and return of solid waste to the business sector, for reuse, in its cycle, in other productive cycles, or another environmentally rigorous destination. The law determines who is obliged to structure and implement reverse logistics systems to increase recycling and reduce the deposit of waste in landfills. Concerning the CW, the NPSW clarifies that the construction companies are subject to the elaboration of a solid waste management plan, by the regulations established by the bodies of the National Environment System. This management plan must comply with the Municipal Solid Waste Management Integrated Plan.

Law 14.026 (BRASIL, 2020), called the new regulatory framework for basic sanitation, encourages competition, and the privatization of state-owned public sanitation companies, among other innovations to reduce environmental and public health problems caused by insufficient sanitation in Brazil (BRASIL, 2020). The law establishes goals for universal sanitation and new deadlines for the closure of dumps by municipalities. It is worth mentioning that laws 11.445 and 14.026 have common points for the treatment of solid waste, as well as law 12.305. In addition, it makes provision for the rationalization of water consumption, by demanding that new condominium buildings must adopt environmental sustainability standards, such as the individualized measurement of water consumption by real estate unit (BRASIL, 2020).

Resolution 307 of the National Environment Council (CONAMA) established guidelines, criteria, management procedures, and the classification of civil construction waste into four classes (Class A, B, C, and D) to facilitate environmentally correct final disposal (CONSELHO..., 2002). The Resolution also instituted the Municipal Construction Waste Management Plan, which includes actions related to the transport, receipt, sorting, storage, or CW final disposal. The Plan establishes that the generators of CW must be responsible for the residues from the construction, renovation, repair, and demolition activities of structures and roads, as well as those resulting from the removal of vegetation and excavation of soils. The other resolutions (348, 431, 448, and 469) implement and update some directive information for the effective reduction of the environmental impacts generated by the CW (CONSELHO..., 2004; 2011; 2012; 2015).

The Action Plan for Sustainable Production and Consumption (PSPC) directs the actions of the government, the productive sector, and society towards more sustainable patterns of production and consumption (MINISTÉRIO..., 2014). It is a goal-based plan with progressive implementation and a participatory approach, reflecting advances in other public policies. In its first cycle (2011 to 2014) it sought to strengthen existing initiatives and voluntary adhesions and demonstrating measures aimed at promoting changes in production and consumption patterns. The initiatives established in the Sustainable Constructions area sought to introduce practices that improve socio-environmental performance, from the project to the construction, considering the selection of materials and alternatives that have less impact on the environment and human health (MINISTÉRIO..., 2014). The main guidelines concerning the circular principles were the promotion of programs that seek energy efficiency, the rational use of water and its reuse, the use of environmentally friendly materials and techniques, and waste management.

Categorization of Brazilian public policies

The complexity of Brazilian public policies and the numerous instruments and objectives related to each law makes the political scenario influence the relationships between stakeholders of the construction value chains and between the stages of the building's life cycle. To better understand and combine the law instruments, to promote actions and mediate conflicts, the identification of the axes of political intervention is important. Table 2 presents the categorization of the main instruments present in each public policy according to the five thematic axes established by Doranova *et al.* (2016). It is worth noting that no voluntary measures were observed in the analyzed public policies.

Law 9.795 (BRASIL, 1999) presented lines of action linked to school and education to develop an integrated understanding of the environment in its multiple and complex relationships. In-Law 10.257 (BRASIL, 2001), regulatory and economic instruments were highlighted regarding the use and planning of urban territory. The instruments aim at the regularization of constructions, reforms or expansions carried out, the optimized use and occupation of the soil and buildings, considering the environmental impact resulting from them to obtain the licenses or authorizations for construction, expansion, or operation under the responsibility of the Municipal Government.

Laws 11.445 (BRASIL, 2007) and 14.026 (BRASIL, 2020), on basic sanitation, presented regulatory, economic, research, and information support instruments. Both laws establish fundamental principles for obtaining more sustainable buildings by stimulating the development of water supply, sewage, urban cleaning, and solid waste management services appropriately for public health, the conservation of natural resources, and the protection of the environment. Law 14.026 (BRASIL, 2020) also encourages the reduction and control of water losses and the promotion of energy efficiency.

The regulatory instrument of Law 12.187 (BRASIL, 2009) is the reduction of GHG emissions in the construction sector aimed at increasing the residual life of building materials through circular practices. National targets for reducing GHG emissions in buildings are the main factors for promoting the development of Design for Disassembly (DfD), the reuse of construction materials, and, consequently, the demand for secondary materials in the market.

Law 12.305 (BRASIL, 2010) is the most representative in terms of instruments that contribute to CE in the sector. The information systems and inventories proposed in the law, in the information category, are important instruments for collecting and analyzing data and generating information to guide the decision-making of political and private bodies about solid waste. Sectoral agreements and environmental education are instruments to connect interested parties and promote CW management. The law also provides the development of scientific and technological research for the creation of new products or technologies that aim to slow down, close, and narrow the cycles of resources and materials. Besides, reverse logistics requires greater integration among industry stakeholders and can create new circular business models. The law shows the need for integration between the stakeholders in the construction value chain to enable the implementation of the NPSW and achieve efficiency in the CW reduction.

Resolution 307 (CONSELHO..., 2002) and other amendments present regulatory instruments regarding the classification and final disposal of the different types of CW. Those instruments enable the development of Management Plans and the direction of solutions for solid waste, to consider the political, economic, environmental, cultural, and social dimensions, under the premise of sustainable development.

The PSPC presented instruments to improve the socio-environmental performance of buildings. The Federal Government norms for sustainable housing programs started to incorporate variables such as the use of local resources; saving water and energy in construction; promoting the rational use of building materials; promoting the collection and recycling of solid waste; adopt solutions to improve the internal comfort of homes and promoting environmental education for residents.

Finally, when studying the instruments separately, it is essential to consider that specific actions are not sufficient from the CE point of view, which determines the incorporation of a systemic view. Strategies that consider only economic, environmental, or social issues will not achieve circularity. The implementation of a public policy depends on the engagement of the stakeholders in interconnected and dependent value chains, in articulation with governments, organizations, communities, and individuals.

Table 2 - Categorization of public policies related to CE

Categories	Law 9.795 (BRASIL, 2001)	Law 10.257 (BRASIL, 2001)	Law 11.445 (BRASIL, 2007)	Law 12.187 (BRASIL, 2009)
Regulatory instruments		Spatial planning and economic and social development plans. Legal and political institutes. Environmental Impact Study (EIS) and Neighborhood Impact Study (NIS).	Water supply, sanitation, urban cleaning and solid waste management. Availability of drainage and stormwater management services. Reduction and control of water losses.	National Plan on Climate Change. Action Plans for the Prevention and Control of Deforestation in biomes. Establishment of quantifiable and verifiable standards and targets for the reduction of GHG emissions. Sustainability indicators.
Economic instruments		Tax and financial institutes.	Economic efficiency and sustainability.	Fiscal and tax measures aimed the reduction of GHG emissions. Credit and financing lines.
Research development and deployment	Training; Development of studies, research and experimentation. Production of educational material.		Encouraging research, development and use of appropriate technologies.	Development of research; Records, inventories, estimates, assessments of GHG emissions. Disclosure, education and awareness-raising measures.
Information, capacity building and networking support			Articulation with urban and regional development, housing, anti-poverty and eradication policies, environmental protection, health promotion, water resources social interests.	Stimulate the development of processes and technologies that contribute to the GHG emissions reduction. Establish preference criteria in public tenders, including public-private partnerships.
Categories	Law 12.305 (BRASIL, 2010)	Law 14.026 (BRASIL, 2020)	Resolutions (CONSELHO..., 2002, 2004, 2011, 2012, 2015)	PCPS (MINISTÉRIO..., 2014)
Regulatory instruments	Solid waste plans. Selective collect; reverse logistic; shared responsibility. Environmental and health Boards. Municipal agencies for the control of solid waste services. National Environmental Policy Instruments. Terms of commitment and conduct adjustment.	New deadlines for the environmentally appropriate final disposal of tailings (closure of open dumps). Adoption of individualized measurement of water consumption by real estate unit. Connection of the urban buildings into public water supply and sewage networks available. Progressive reduction and control of water losses.	Resolution No. 307 CCW classification, Plans and proper disposal. Resolution No. 348 Institutes hazardous waste materials containing asbestos. Resolution No. 431 Plaster becomes Class B. Resolution No. 448 New guidelines for Waste. Management Plans. Resolution No. 469 Empty ink packaging - Class B	Sustainable public procurement. Increased recycling of solid waste. Sustainable retail. Sustainable Buildings.
Economic instruments	Tax, financial and credit incentives. National Environment Fund. Incentive to consortia or cooperation.	Stimulate free competition, efficiency and economic sustainability in the provision of services.		
Research development and deployment	Cooperation between the public and private sectors to develop research.	Promote environmental education; technical training of the sector; scientific and technological research.		Education for sustainable consumption.
Information, capacity building and networking support	Inventories and annual solid waste reporting system. Creation of cooperatives of waste pickers. Environmental education. National Information System on Solid Waste Management. Sectoral agreements. Encouraging consortia or cooperation.	Encourage the integration of databases. Encourage cooperation between entities to providing,contracting and regulation of services.		Environmental Agenda in Public Administration.

Circular strategies in a broader policy context

Table 3 shows the impact of Brazilian public policies on different circular strategies. The 9R framework (showed in Figure 1) was adopted as a parameter to analyze the circularity of public policies in the construction sector.

Public policies have actions in different circular strategies, with an emphasis on strategies aimed at prolonging the useful life of materials, which aim to adapt the screening of CW for recycling or recovery of parts of the material, for example, through the incineration of wood as energy fuel. The NPSW features instruments for both recycling and promoting the reuse, repair, or redirection of materials to extend the useful life of resources. Law 10.257 (BRASIL, 2001) uses instruments such as compulsory use and adverse possession that contribute to the reuse/repair of existing buildings and the prolongation of the building's useful life.

Laws 11.445 (BRASIL, 2007) and 14.026 (BRASIL, 2020) encourage the conscious consumption of water and the reuse of effluents and rainwater, reducing pressure on natural resources and stimulating the development of more sustainable technologies and systems for sanitary facilities. The strategy of reducing the extraction of natural resources is encouraged by the reduction of GHG emissions (Law 12.187 (BRASIL, 2009)) and by the PSPC that encourages the increase of efficiency and management of resources and construction materials. Initiatives such as Resolution 348 (CONSELHO..., 2004) also promote a more conscious use of building materials and the well-being of users.

Table 3 - Correlation of Brazilian public policies with the 9R framework

	Strategies	Public policies	Circular instruments
Circular economy	R0 Refuse	-	-
	R1 Rethink	Resolution 348 (CONSELHO..., 2004)	Tiles and other objects and materials containing asbestos are dangerous materials
	R2 Reduce	Law 11.445 and 14.026 (BRASIL, 2007, 2020)	Reduction and control of water losses, encouraging rationalization, and promoting energy efficiency; Adoption of individualized measurement of water consumption
		PPCS (MINISTÉRIO..., 2014)	Takes advantage of the natural resources of the local environment; manage and save water and energy in construction; promote the rational use of construction materials
		Law 12.187 (BRASIL, 2009)	Reduction of greenhouse gas emissions
	R3 Reuse	Law 10.257 (BRASIL, 2001)	Use of unused, underutilized, or unused urban land; Adverse possession of urban property; Regularizing buildings following current legislation
		Law 11.445 and 14.026 (BRASIL, 2007, 2020)	Reuse of effluents and the use of rainwater
		Law 12.305 (BRASIL, 2010)	Selective collection, reverse logistics, and shared responsibility
	R4 Repair	Law 12.305 (BRASIL, 2010)	Solid waste plans; Selective collect, reverse logistics, and shared responsibility
	R5 Refurbish		
R6 Remanufacture			
R7 Repurpose			
Linear economy	R8 Recycle	Laws 11.445 and 12.305 (BRASIL, 2007; 2010)	Solid waste management
		Resolutions 307 and 448 (CONSELHO..., 2002, 2012)	Classification and proper destination of construction waste. Waste management plans
		Resolution 431 (CONSELHO..., 2011)	Plaster as class B recyclable waste
		Resolution 469 (CONSELHO..., 2015)	Reverse logistics for empty paint packaging
	R9 Recover	Law 14.026 (BRASIL, 2020)	Extinction of open pit dumps

Public policies have a concentration on less circular strategies. Law 14.026 still establishes the need to extinguish open-air dumps. CONAMA resolutions focus on raising awareness of the need to separate and classify CW. Although the current political framework has numerous circular instruments, it is necessary to create a centralized strategic plan with measures to foster research, technologies, and circular business models that promote the development of the CE in a manner compatible with the need for national economic development.

Discussion

The transition to a CE in the construction sector is still incipient and lacks systemic thinking. It is possible to find links between Brazilian legislation and policy guidelines that relate to and contribute to the introduction of circular principles in the sector, however, there are no specific public policies and efforts are lacking for the application and consolidation of the existing ones. For Guarnieri, Cerqueira-Streit and Batista (2020) this fact demonstrates the lack of awareness and understanding of the fundamental role that a sectoral agreement can play in enabling industrial transitions to the CE.

The choice of NPSW as a national example of propositions capable of directing the circular transition process is justified by principles such as non-generation, reduction, reuse, and recycling of solid waste. This law highlights the importance of a systemic view of construction value chains, reducing resource consumption, and recognizing the economic and social value of waste. The law does not act in isolation but is characterized by articulating with policies regulated by other legislation, such as the National Basic Sanitation Policy, the NPCC, and the PSPC. The institution of reverse logistics promotes new circular business opportunities, the use of by-products, and the establishment of secondary material markets. However, its operation faces challenges due to the absence of carbon-neutral targets; absence of specific objectives; lack of coordination between manufacturers, distributors, and traders for an efficient process of storage, collection, and recycling; and lack of technology, infrastructure, and qualified knowledge (GUARNIERI; CERQUEIRA-STREIT; BATISTA, 2020; JABBOUR *et al.*, 2014). The authors argued that the barriers to the implementation of reverse logistics also apply to the obstacles that hinder the CE implementation.

There is a need for a better understanding of the CE principles, and fundamentally, the public policies need to be reformulated focusing on the preservation of resource value instead of the efficiency in waste management. This must discuss within the reach of everyone involved in the construction value chains, from architects, builders, to users and recyclers, who are sometimes unaware of the importance of their performance or the harmfulness of certain conducts. Defining objectives for the sector and demanding its effectiveness seems to be of paramount importance and, perhaps, the only way to introduce circular principles and achieve sector sustainability.

The study showed the profile of Brazilian public policies is concentrated on regulatory instruments at the organizational level, characterizing the pioneering essence of governance in adopting the circular model. Other countries such as China and Japan already have a more structured policy framework. In 2009, China pioneered the establishment of specific legislation aimed at the CE, with a focus on the symbiotic relationships of industrial parks (IWASAKA, 2018). Japan, since 1991, has been showing a progressive evolution in policies aimed at the cyclical use of materials (GHISELLINI; CIALANI; ULGIATI, 2016).

The European Union's efforts have been taking place since 2008, and each member country has been applying efforts according to their local realities. For example, Germany is a pioneer in actions related to solid waste management, with an action implemented in 1976 aimed at regulating the flow of packaging and products (GHISELLINI; CIALANI; ULGIATI, 2016). The Netherlands implemented a national strategy for the implementation of CE in the country by 2050, focusing on the stages of the materials production process, seeking to disseminate attractive circular alternatives (IWASAKA, 2018). Since 2014, the United Kingdom has been applying economic measures, such as taxation, and different rates applied to products that incorporate some CE principles (IWASAKA, 2018). The more advanced development of other countries, such as the European ones, directs new opportunities for Brazilian public managers to formulate policies aimed at CE. Local, regional, and national authorities must guarantee policies, regulations, and financial support; facilitate dialogue between companies, civil society, and research organizations; and lead or participate in the development of projects (DORANOVA *et al.*, 2016).

Conclusions

This study presented the main Brazilian public policies related to the implementation of CE in the construction sector. When considering the scope of the public policies, Brazilian legislation is already reasonably adhering to the concept of the CE. The NPSW addresses in an orderly manner the main issues related to the production and destination of solid waste in the country. However, despite being a consistent legal framework, the great challenge is the correct execution of this policy, in an integrated manner between the Union, States, Municipalities, and the private sector.

This study aims to expand the discussion on the importance of circular public policies and to support policymakers develop a circular plan based on a set of policy tools and measures to regulate resource efficiency, waste reduction, and management and create a more sustainable sector. For academics, managers, practitioners, and researchers, it can direct and expand knowledge about the potential applications of CE, as well as about the implementation of reverse logistics and circular principles relevant to the management of solid waste in the sector.

This study has as its main limitation the non-comprehensiveness of the whole Brazilian legislative framework for analyzing the proposed problem. The selection of the twelve public policies were based on previous readings, on the PSPC report, and the analysis of Federal laws aimed at sustainability, not including municipal and state laws. Additional studies could cover other governmental perspectives that contribute to CE implementation and in the non-governmental organizations. In addition, future research could analyze the development of circular policies in other countries, to direct national actions towards a governance plan that considers and applies CE principles.

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