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Review Article

Circular economy in Latin America and the Caribbean: Drivers, opportunities, barriers and strategies

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ABSTRACT

This study assesses for the first time the drivers, opportunities, barriers, and strategies for the transition to a circular economy in Latin America and the Caribbean through a comprehensive systematic review of the current academic literature. A total of 247 articles have been analysed through the lens of the PESTLE framework (Political, Economic, Social, Technological, Legal, and Environmental), coupled with the consideration of the most recognised circular economy strategies (narrowing, slowing, closing, and regenerating) and solutions (the ten R's strategies: refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, and recover). Key drivers identified in the literature include governmental policy shifts in the region towards circular and sustainable practices. These practices have focused on leveraging the abundance and diversity of natural resources and the region's climatic conditions that favour the development of bio-industries, renewable energies, and innovative sustainable materials, reflecting a clear adaptation of circular economy strategies to the specific needs and resources of Latin America and the Caribbean. Similarly, the technological and regulatory progress in pollution prevention and control, although still slow, has driven the implementation of circular economy strategies, making the role of new circular technologies fundamental for the region's sustainability. Barriers mentioned in the articles include limited governmental incentives, inadequate infrastructure for waste management, and the high costs associated with transitioning to circular economy practices, compounded by a lack of general public awareness and engagement. Regarding the circular economy strategies, the reviewed studies predominantly focus on recycling ("closing") due to the immediate waste management needs of the region, with less emphasis on resource efficiency ("narrowing" and "slowing") and minimal adoption of regenerative practices due to higher initial investment demands. Recycling and, to a lesser extent, recovery dominate the ten R's strategies discussed in the literature, indicating still a focus on end-of-life approaches in the region, while strategies like reduce, reuse, and repurpose are gaining representation; however, research on repair, refuse, remanufacture, and refurbishment should be the focus of future investigations. Finally, this article provides guidelines and recommendations for future research to facilitate the deployment and management of a sustainable circular economy in the region.

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1. Introduction

The necessity to transition from a linear to a circular economy (CE) has gained significant traction worldwide, echoing the pressing need for a more sustainable approach to production and consumption (Achinas and Willem Euverink, 2020; Cruz et al., 2021). This paradigm shift is underscored by international organisations, such as the Ellen MacArthur Foundation (2015) and the European Commission (2020) which recognised the limitations of the conventional linear production system. Achinas and Willem Euverink (2020) and Cruz et al. (2021) outline that this transformation is contingent upon multifaceted factors, encompassing new policies, financial structures, technological developments, educational and upskilling programs, and widespread awareness among the general public. The intricate interplay between CE initiatives and governmental policies becomes evident in the work of (Chiappetta Jabbour et al., 2020), which highlights how CE practices can be integrated into processes, technologies, and products, but only if there is supportive governmental action. However, this symbiotic relationship faces challenges in emerging economies, where palpable governmental and financial support for CE practices is often lacking (Silva et al., 2019; Chiappetta Jabbour et al., 2020). Nevertheless, the significance of the CE in achieving the Sustainable Development Goals (United Nations, 2015) has been repeatedly emphasised, positioning it as an essential element for addressing global resource, environmental and socio-economic challenges through active collaboration between countries from both the Global South and North (Geissdoerfer et al., 2017; Rodríguez-González et al., 2022).

The significance of embracing CE principles in Latin America and the Caribbean (LAC) arises from a confluence of environmental, economic, and social challenges. As highlighted in the report of the Circle Economy Foundation (2023), LAC's share of global material extraction is substantial at 11.2 %, despite comprising only 8.3 % of the global population. Between 2004 and 2017, over 43 M hectares were deforested due to agriculture, livestock production, mining, transportation and fires (ibid). Moreover, there has been a 90 % decline in biodiversity as well as 14 % of soil degradation (> 40 % in some countries) (ibid). Likewise, the region is suffering a 1.7 % annual loss in Gross Domestic Product (GDP) as a result of climate change (expected to increase up to 10 % of the region's GDP by 2050 = $22B/yr) despite accounting for only 10 % of global greenhouse gas (GHG) emissions (Schröder et al., 2020).

While the region is self-sufficient in the extraction, processing, and use of raw materials, the minimal material ‘cycling’ (defined as the process of converting waste materials into new materials and objects), with <1 % of circularity in the region (Circle Economy Foundation, 2023), represents a missed opportunity for sustainable resource utilisation. Likewise, the environmental burden (e.g., land use, biodiversity loss) related to material extraction and processing in LAC is exacerbated by the exponential rise in global material demand, also leading to social issues (e.g., inequalities, human health problems) (ibid). The pressing issue of food waste in countries like Brazil, where approximately 20 % of food is wasted, further emphasises the need for CE interventions (Sehnem et al., 2022). Inefficiencies in conventional waste management practices across LAC, where over two-thirds of waste is disposed of in landfills, also contribute to negative environmental impacts (Lara-Topete et al., 2022). However, the adoption of CE practices by small and medium-sized enterprises (SMEs) in developing economies, including LAC, which represents 20 % of the GDP (Lardizabal and Zhang, 2022), is still at a nascent stage, highlighting the importance of establishing strong strategies and collaborations between businesses, customers, and regulatory bodies (Hutner et al., 2017; Preston and Lehne, 2017).

Transitioning to a CE in LAC involves environmental and economic considerations and an integration of social aspects. CE solutions can address income inequality, promote social justice, foster inclusiveness, including the formalisation of informal sectors, and enhance employment quality through upskilling (Circle Economy Foundation, 2023; Dewick et al., 2022). Additionally, it is crucial to analyse the intersection of the CE with Industry 4.0 technologies, which necessitates considerations of training costs and technological adaptation (Rodríguez-González et al., 2022). The impact of a CE on biodiversity remains uncertain, particularly in a region as geographically and biologically diverse as LAC, which is highly dependent on natural resource extraction and commodity exports (Schröder et al., 2020). Balancing economic objectives with environmental sustainability is essential, especially in areas rich in primary forests and mineral resources (Dewick et al., 2022; Schröder et al., 2020). Higher urbanisation rates in LAC further complicate waste management, with daily municipal waste generation at about 541,000 t, expected to increase by 25 % by 2050, coupled with significant food loss and untreated wastewater (Schröder et al., 2020). Consumer behaviour, influenced by socio-economic factors, poses additional hurdles to CE adoption, necessitating tailored strategies (Ospina-Mateus et al., 2023; Uriarte-Ruiz, 2022). Overcoming specific challenges such as deforestation and energy supply issues requires nuanced policy formulation addressing infrastructure, finance, and education (Ospina-Mateus et al., 2023; Souza Piao et al., 2023). Therefore, it is imperative to address these diverse factors to develop comprehensive CE strategies tailored to the unique characteristics and challenges of LAC and the Global South.

The existing body of scientific literature on the territorial deployment of CE strategies predominantly draws on results from Asia, Europe, and North America, often neglecting a comprehensive examination of low- and middle-income countries (Ddiba et al., 2020). For instance, Kirchherr and van Santen (2019) scrutinised 160 CE papers, revealing that only 5 % focused on emerging economies. Notably, LAC is substantially lacking empirical evidence in this regard (Aguilar et al., 2022). Nevertheless, some literature reviews have started to concentrate on the intersection of the CE and LAC in recent years. Salvador et al. (2022) provide a status on CE, as well as practice gaps, and make recommendations to accelerate it in LAC, but address specifically the bioeconomy of the region, being the remaining sectors out of the scope of their research. Betancourt Morales and Zartha Sossa (2020) identified key barriers, including limited awareness, lack of supportive policies, and financial constraints, while also highlighting opportunities such as job creation and innovation. The authors, similarly to Ospina-Mateus et al. (2023) focus on bibliometric analysis and conceptual comparisons between Europe and LAC. However, according to Betancourt Morales and Zartha Sossa (2020), there is a lack of recent academic literature updates, and a limited representation of LAC sources, as only 5 % of the articles in the review originate from this region. Tonon Ordóñez and Andrade Carrasco (2023) specifically examined barriers in waste management and recycling, cultural factors, and the prevalence of linear economic models while emphasising some potential generic benefits of circular practices in LAC (e.g., job creation). Despite its insights, the article lacks a critical analysis of the literature through the lens of CE frameworks. The significance of embracing CE principles in Latin America and the Caribbean (LAC) arises from a confluence of environmental, economic, and social challenges, which are influenced by micro (e.g., access to technology for innovation), meso (e.g., collaborations among stakeholders in the value chains), and macro-level (public policies, incentives, and financial mechanisms related to the adoption of CE practices) factors (Van Hoof et al., 2023). Meanwhile, Soto-Rios et al. (2023) explored circular pathways in LAC but only concentrated on the water and wastewater sectors. Similarly, Matus et al. (2023) conducted the first evaluation of the economic and environmental impacts of investments in circular technologies for wastewater plants across a broad range of countries in LAC. The study found that implementing CE technologies yields an approximate benefit/cost ratio of 1.36 and reduces emissions by 88 %. However, the authors also highlighted that most existing CE implementation cases are located in Europe or Asia, indicating a need for further research in LAC countries. Besides the academic literature, other publications, such as factsheets, have captured elements of CE in LAC, but also focused on specific sectors and countries, such as Flores Montalvo and Loutfi Olivares (2020), by providing insights into how single-use plastic waste in Mexico can be reduced through circular economy initiatives. Therefore, an updated and comprehensive review of academic literature on the CE in LAC, to analyse key challenges and opportunities, as well as areas for practical intervention and innovation, using specific CE and sustainability frameworks as lenses for analysis, is still lacking, which is addressed in this study.

Consequently, this study provides a novel examination of the key drivers, opportunities, and barriers in LAC concerning the transition to a CE drawing on current academic literature. The comprehensive analysis is approached for the first time through the lens of the PESTLE framework (Political, Economic, Social, Technological, Legal, and Environmental) (Fig. 1) coupled with CE strategies (narrowing, slowing closing, and regenerating) and the ten R's strategies (refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle and recover). Results aim to be useful for researchers, policymakers, economists, and industry professionals, providing a research agenda that can stimulate future investigations and influence and boost the deployment of a sustainable CE not only in LAC but in the whole Global South.

2. Methodology

A systematic literature review was conducted following the 'Preferred Reporting Items for Systematic Reviews and Meta-Analysis' (PRISMA) guidelines (Page et al., 2021). PRISMA is an evidence-based checklist developed to guide systematic reviews (Nadaraja et al., 2021). The PRISMA 2020 statement provides updated reporting guidance that incorporates advancements in methods for identifying, selecting, appraising, and synthesizing studies, thus enhancing clarity, transparency, and integrity in systematic review reports while ensuring methodological rigour (Nadaraja et al., 2021; Page et al., 2021; Siddique et al., 2024). The search encompassed articles published up to December 2023 in the Scopus and ScienceDirect databases, with the starting point for the review set in 2008 to focus on more recent conceptual CE approaches, which have been primarily driven since that year through the activity carried out by the Ellen MacArthur Foundation. The search string included "circular*" AND "CE solution" (37 different keywords) AND Latin American and Caribbean countries (Table S1 in Supporting Information (SI)). The 37 keywords related to "CE solutions" included: remanufacturing, durability, refurbishment, servitisation, sharing, "closed-loop", "product service systems", "material circularity", reuse, maintenance, repair, upgrade, upcycling, upgrading, "reverse supply chains", refuse, rethink, reduce, refurbish, narrowing, closing, slowing, regenerating, nano, micro, macro, meso, "circular supplies", "reverse logistics", cascading, "take back systems", "industrial symbiosis", "by-product exchange", repurpose, recover, "extended producer responsibility" and cycling. These CE keywords were extracted from pertinent articles on the CE, including Kirchherr et al. (2017), Velasco-Muñoz et al. (2021), and Gallego-Schmid et al. (2020), where these concepts are explored.

To narrow down the literature search to papers specifically centred around the ongoing and emerging research on the CE, broader terms, such as material or resource efficiency, eco-design, or sustainability were excluded. For LAC countries, the following terms were used "Latin America", "South America", "Central America", Caribbean, Southamerica, Argentina, Brasil, Brazil, Colombia, Guyana, Surinam, Venezuela, Bolivia, Chile, Ecuador, Peru, Uruguay, Paraguay, Belice, Belize, "Costa Rica", "El Salvador", Guatemala, Honduras, Nicaragua, Panama, Antigua, Barbuda, Bahamas, Barbados, Cuba, Dominica, Granada, Haiti, Jamaica, "Republica Dominicana", Dominican, "Saint Kitts", "Nevis", "Santa Lucia", "San Vicente y las Granadinas", "Grenadines", Trinidad, Tobago, and Mexico. The keywords were searched in the title, abstract, or list of keywords using the advanced search field code of Scopus and ScienceDirect.

As illustrated in Fig. 2, a total of 1831 documents were identified, which were filtered using the following inclusion criteria:

- All types of documents written in English, such as reviews, articles, conference papers, abstracts, mini-reviews, book chapters, editorials, encyclopedias, short communications, discussions and case reports were considered.
- During the search process, the initial matches were screened by directly reviewing the titles and abstracts. Articles were excluded if

Fig. 1. Components of the PESTLE analysis. Adapted from Mihailova, M. (2020).

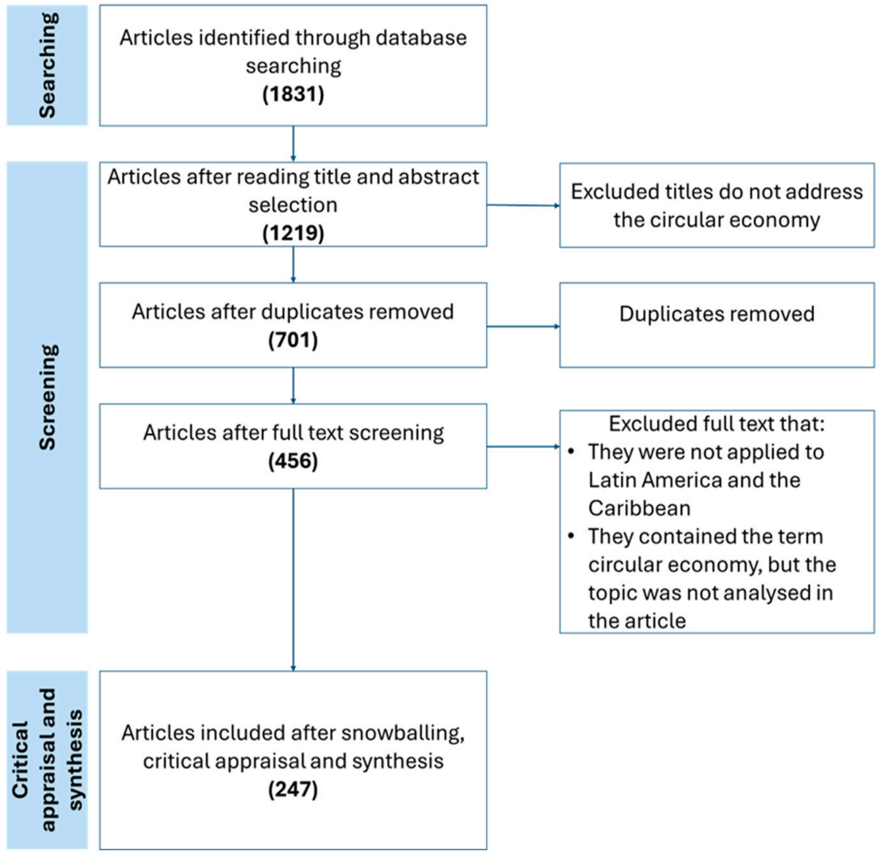

Fig. 2. Methodology for the systematic literature review. Adapted from Page et al. (2021).

the CE was not the primary focus of the research (e.g., not explicitly mentioned), reducing the selection to 1219.

- Since several articles referenced more than one of the search engine keywords, some articles appeared multiple times across different searches. Consequently, duplicate articles (518) were removed. The remaining papers (701) were examined to select the ultimate sample. Articles that included the term circular economy, but did not focus on it and/or LAC were eliminated (245) and the remaining (451) were fully screened.
- Once a document was selected for review, a 'snowball' method was employed to search for additional relevant papers by looking at the document reference list or citations (Wohlin, 2014). However, the articles identified through the 'snowball' method (Wohlin, 2014) were the same as those found in the initial search, so the total number of articles did not change.
- Consequently, 247 studies were finally selected for review (see Table S2 in SI).

From a geographical perspective, the countries with more CE studies were Brazil (58 % of the articles), Mexico (12 %), Bolivia (6 %) and Chile (5 %) and from a sector perspective, waste treatment (32 %), manufacture (11 %), energy transformation (11 %), and agriculture (8 %). Concerning the scales of the CE implementation, almost half of the articles analysed focused on the macro scale (49 %) (city, country and region), followed by the nano (19 %) (products and services), micro (18 %) (companies and business models), and meso (14 %) (industrial areas, neighbourhoods) scales.

3. Results and discussion

This section analyses the key drivers and opportunities (subsection 3.1), barriers (subsection 3.2), CE strategies (subsection 3.3), and R's strategies (subsection 3.4) addressed in the reviewed studies.

3.1. Drivers and opportunities

Table 1 shows various drivers and opportunities for CE implementation in LAC that have been identified and analysed from a political, economic, social, technological, legal and environmental (PESTLE) perspective (see Table S3 in SI for the literature references). Drivers represent factors known to contribute to facilitating and/or accelerating the implementation of CE strategies (Salvador et al., 2022). These factors may include environmental conditions, prior knowledge, business awareness (Piispanen et al., 2022), policies, or technological advancements (Salvador et al., 2022). Generally, opportunities arise from changes in the environment in which an individual or organisation operates. These changes create an imbalance that can potentially be exploited, such as technological, policy, and regulatory opportunities, as well as social and demographic shifts (Mary George et al., 2016). Recognising these opportunities can create positive and favourable circumstances that lead to business actions (Mary George et al., 2016). In this context, a policy, for example, can serve as a driver for the development of a CE, as well as generate opportunities for new businesses or job creation. Due to the close relationship between these concepts, they have been jointly identified in this research (Table 1).

3.1.1. Political

The CE presents significant opportunities to create new policies and legislation aimed at promoting sustainability in LAC. One example is the Brazilian National Policy on Solid Waste (Presidência da República, 2010), which mandates comprehensive recycling and collection processes, highlighting the governmental commitment to environmental management (Barquete et al., 2022; Fidelis et al., 2020; Fuss et al., 2018). The new policy framework associated with waste management

Table 1
Drivers and opportunities of the circular economy for Latin America and the Caribbean.

Dimension	Drivers and opportunities
Political	Development of new policies aimed at promoting sustainability Prioritisation of the implementation of currently available waste management and recycling policies Increasing environmental and economic benefits from the development of policies supporting bioenergy
Economic	Opportunities to diversify income sources across various economic sectors Reduction of production costs through the use of waste Creation of new and more sustainable business and employment opportunities.
Social	Opportunities to foster community development Significant progress in social inclusion and service improvement Greater public engagement and education Creation of new jobs and businesses
Technological	Resource extraction reduction Technological advances to increase production efficiency Biomass availability and use as a renewable energy source Opportunities for the development of new sustainable materials and products Increasing the use of recycled and recovered materials Innovation and development of new technologies to improve the environmental, social, and economic performance
Legal	New waste management and recycling legislation New legislation for sustainable energy generation Minimisation of environmental impact and improvement of natural resource management through legislation High potential to address social and inclusion aspects through legislation
Environmental	Environmental benefits of recycling and waste management Reduction of greenhouse gas emissions Reduction of other environmental impacts Environmental benefits of bioenergy Environmental benefits of energy recovery and efficiency

not only emphasises material recycling but also recognises the vital role that informal waste collectors in LAC have played before the development of waste management policies (Fidelis et al., 2023). For example, informal collectors in Brazil are responsible for 89 % of municipal solid waste (MSW) management with recyclable potential that returns to industries as raw materials (ibid). By providing access to financial support programs, these policies facilitate the inclusion of informal waste pickers in the formal waste management sector (Fidelis et al., 2023, Fidelis et al., 2020). Policies that facilitate, for example, the reintroduction of packaging waste back into the production cycle, yield environmental benefits and support waste collectors' socioeconomic advancement, underscoring the fundamental role of reverse logistics in facilitating the transition to a CE (Guarnieri et al., 2020). Moreover, several authors emphasise the importance of the participation of all key public and private stakeholders in the development of sector-specific policies (Da Silva, 2018; Ellen MacArthur Foundation, 2015; Guarnieri et al., 2020). An example is the Chilean Extended Producer Responsibility and Recycling Promotion Law (Gobierno de Chile, 2016), enacted in 2016, where producers, importers, municipalities, generators, consumers, and informal waste collectors were involved from the initial stages.

Governmental support and political influence serve as crucial drivers for promoting advances in recycling technologies and waste management approaches in LAC (Ibelli-Bianco et al., 2022; Korsunova et al., 2022; Sala-Garrido et al., 2023). For example, adopting and enforcing water resource regulations for achieving sustainable agricultural water use are crucial in LAC, where the bioeconomy is key (Dziedzic et al., 2022). The circular economy strategies have been implemented to valorise the expanded polystyrene household waste (Hidalgo-Crespo et al., 2020), sugarcane waste in Brazil (Rossetto et al., 2022) and to recycle batteries (Levänen et al., 2018). Treating wastewater for agricultural use is a CE practice that reduces costs and minimises discharges into water bodies (Dziedzic et al., 2022). Also related to the bioeconomy, the production of bioenergy from agricultural waste has significantly advanced due to regional policy initiatives, such as energy recovery from açaí seeds (Maciel-Silva et al., 2021). In Brazil, anaerobic digestion (AD) has been promoted to combat eutrophication from livestock activities, and supported by specific state biogas policies (Barquete et al., 2022; Nadaleti et al., 2021b). In the construction sector, recent governmental regulations and technical standards have started to include the mandatory use of Building Information Modeling (BIM), recycled waste and prefabricated modules in new public buildings (Barquete et al., 2022).

3.1.2. Economic

The potential economic benefits associated with increasing circularity in the bioeconomy is one of the main drivers in LAC (Weber et al., 2020). The Argentinian citrus industry exemplifies how waste and by-products can be valorised, reducing environmental impacts while maintaining profitable production (Machin Ferrero et al., 2022). Similarly, the energy recovery through AD from livestock waste can help to reduce costs in the meat sector in Brazil, because the produced biogas can reduce about 60 % of the energy costs (Hollas et al., 2022; Nadaleti and Lourenço, 2021). Furthermore, the efficient use of urea and the application of industrial waste as a nutrient source in agricultural soils have proven to help improve sustainability and reduce production costs (Fink et al., 2021). This is crucial in LAC, where soil fertility challenges require sustainable nutrient management to ensure crop yields without escalating costs (Santos et al., 2020). Valorising agricultural waste for food packaging materials can help extend the shelf life of foods while also addressing environmental concerns related to non-biodegradable packaging (Orqueda et al., 2022). Finally, biorefineries can create new, more sustainable business and employment opportunities, add value to regional raw materials, and use waste as a renewable resource (Weber et al., 2020).

Beyond the bioeconomy, CE practices also show potential economic benefits in other key sectors from LAC. For instance, CE strategies have shown significant financial returns of investments in the automotive industry in Mexico through the reuse and recycling of components and materials in new and second-hand vehicles (Rodríguez-González et al., 2022). The reverse remanufacturing of Electrical and Electronic Equipment (EEE) and Waste Electrical and Electronic Equipment (WEEE) is a market with significant potential in LAC, as it can generate new employment and income opportunities (Brito et al., 2022). In developing countries, where MSW and construction and demolition waste (CDW) are deposited in open landfills, recycling offers a viable strategy to reduce costs and environmental impacts associated with decreased landfill use and raw material consumption (Ferronato et al., 2023c; Torres de Sande et al., 2021).

3.1.3. Social

Transitioning towards a CE in LAC paves the way to foster community development (Aguiñaga et al., 2018). Initiatives in several LAC countries have shown significant progress regarding social inclusion within the context of the CE and waste management, particularly trying to integrate resource recovery into urban planning (Basnak and Giesen, 2023). For example, Colombian local initiatives and educational efforts have shown how resource recovery from organic waste can be integrated into urban planning (Aguilar et al., 2022). Moreover, general public engagement and education play a fundamental role in improving waste management and supporting a CE (Aguilar et al., 2022; Duarte Castro et al., 2022; Ferronato et al., 2020a). In Mexico City, the total amount of waste diverted increased by 65 % from 357.94 t in 2014 to 591.50 t in 2019 due to extensive citizen participation and educational campaigns (Kutralam-Muniasamy et al., 2023). More specifically, including informal recycling sectors and empowering waste collectors through education and training are crucial for the successful implementation of CE models (Ferronato et al., 2022a; Ibelli-Bianco et al., 2022). Finally, the advancement of CE models in LAC also plays a fundamental role in creating new jobs and promoting socially inclusive business opportunities in traditional sectors such as the bioeconomy (e.g., biorefineries, use of biomass or transforming waste into valuable bioproducts) or the treatment of WEEE (Aguiñaga et al., 2018; Gutberlet et al., 2020; Reis Neto, 2021), but also in emerging sectors such as lithium-ion battery (LIB) and expanded polystyrene (EPS) recycling (Brito et al., 2022; Costa et al., 2022; de Oliveira et al., 2019; Weber et al., 2020).

3.1.4. Technological

Technological advancement enables the reduction of resource extraction through the optimisation of raw materials and inputs, as well as, the valorisation of industrial waste (Santos et al., 2020). For example, in Brazil, sugar cane production can achieve a high level of circularity through the generation of bioethanol and the improvement of agricultural practices by: i) maximising the use of waste and nutrient recovery; ii) reducing the use of machinery through GPS-based traffic control, iii) and increasing manual harvesting. This sector has integrated economic, environmental, and social sustainability goals and contributed to bioenergy generation and to mitigate GHG emissions (Rossetto et al., 2022). Water resource management also plays a critical role in agricultural efficiency, where applying CE principles can significantly reduce water scarcity (Dziedzic et al., 2022).

The availability of biomass and the region's favourable climatic conditions have made renewable energies economically viable and competitive against fossil fuels (Del Borghi et al., 2022; Reis Neto, 2021). For example, the pyrolysis of Brazil nut waste represents a viable way to convert biomass into energy and produce briquettes, which helps reduce deforestation in the Amazon (Colpani et al., 2022). Similarly, AD in Brazil has proven its capacity to combat eutrophication and promote the circular bioeconomy through the production of energy, fertilisers, and other bioproducts (Magnusson et al., 2022; Mühl and de Oliveira, 2022). Exploring second-generation biodiesel demonstrates the potential for environmental conservation and the production of alternative fuels. This approach does not compete with food resources and offers a solution for sustainable agricultural production in areas unsuitable for conventional crops (Prucca et al., 2023). Finally, the potential to use renewable energy for hydrogen production positions countries in the region as strategic competitors in clean energy generation on the global stage, highlighting their potential to boost regional GDP while reducing energy dependency (Nadaleti et al., 2020).

The availability of biomass in LAC countries not only generates opportunities for renewable energy generation but also for innovation and the development of sustainable materials and products (Braz and de Mello, 2023). The abundant agro-industrial waste in the region has high potential as a source of bioactive compounds. Extracting value-added products from waste adds value to the food, nutraceutical, pharmaceutical, and cosmetic industries (de Souza Silva et al., 2021). In the forestry industry, the potential substitution of coniferous biomass with non-coniferous is expected to change the competitiveness of forest industrial regions in South America, Asia, and Africa due to factors like short rotation forestry and globalisation (Lauri et al., 2021). Moreover, the development of the CE has notably increased the use of recycled biomass, affecting industries such as paper and cardboard by increasing the proportion of recycled pulp (Lauri et al., 2021).

CE-related innovation and technological development are also important drivers and can help improve environmental, social, and economic outcomes (Lopes de Sousa et al., 2022). Tax incentives, access to financing, and a culture favourable to innovation and entrepreneurship are key factors for these developments (de Moraes et al., 2023). Examples of CE innovations in LAC include the development of green polyvinyl chloride (PVC) (Correa et al., 2019), alternative protein products (de Moraes et al., 2023), new thermal insulation materials from biomass waste (Cano et al., 2020; Diniz et al., 2021), and the recycling of end-of-life tyres (Martínez, 2021). These innovations provide solutions to particular problems of the region, like the management of hard-to-treat waste or particulate matter pollution associated with heating, and help to capitalise on specific characteristics of LCA, like the rich biodiversity (de Moraes et al., 2023).

3.1.5. Legal

Legislation is one of the main drivers for waste management and recycling in LAC and, therefore, a necessary instrument for environmental management. For example, Brazil has been a pioneer in banning uncontrolled landfill disposal, requiring municipalities to establish specific recycling targets, and promoting the inclusion of informal waste pickers (Fidelis et al., 2023). In La Paz (Bolivia), introducing national regulations and city-level commitments has paved the way for improved MSW management plans, aiming to increase recycling rates (Ferronato, 2021).

Legislative initiatives have also been crucial in supporting sustainable energy generation, addressing energy demand, managing waste, and reducing GHG emissions (Oliveira Pavan et al., 2021) in the region. Brazil's National Policy on biogas and biomethane (Palácio do Governo, 2018) has set a precedent for legal frameworks supporting the biogas value chain (Hollas et al., 2022; Magnusson et al., 2022). The introduction of specific laws in Colombia has provided incentives for waste-to-energy (WtE) in line with the country's strategy to reduce the amount of waste sent to landfills and promote the energy recovery of MSW (Gutiérrez et al., 2021). Mexico's Energy Reform (Gobierno de México, 2015) promotes electricity generation from renewable sources, particularly solar energy (Santoyo-Castelazo et al., 2021).

Environmental legislation enables the minimisation of environmental impacts and improves the management of natural resources. For example, water resource legislation in some LAC countries has significantly influenced the reduction of water use in agriculture (Dziedzic et al., 2022). Moreover, the legal framework associated with Brazil's National Policy on Food Security and Nutrition has played a crucial role in reducing food loss and waste (Berardi et al., 2020). This legislation has improved resource efficiency, addressed hunger and minimised the need for production and resource extraction (Berardi et al., 2020). CE-based laws also foster social equity, enhance legal compliance, and create sustainable communities in LAC (Dziedzic et al., 2022). In Brazil and Chile, integrating waste collectors into the waste management system through legislation has been crucial for advancing material collection and sorting (Guzzo et al., 2022).

3.1.6. Environmental

Table 1 outlines the most extensively addressed environmental sustainability-related drivers and opportunities in the analysed literature. Notable examples in LAC include the mitigation of deforestation in the Amazon due to the energy valorisation of nut waste (Colpani et al., 2022); the improvement of soil fertility through the use of biosolids (Amorim Júnior et al., 2021; Fink et al., 2021; Mühl and de Oliveira, 2022); the use of byproducts from the fishing industry and insects for biodiesel production in substitution of fossil fuels (Aguilar-Murguía et al., 2022; Monsiváis-Alonso et al., 2020); and the mitigation of climate change thanks to the reduction of methane emissions through the composting of MSW (Carvalho Machado and Kindl Da Cunha, 2022; Ferronato et al., 2023c); and the adoption of first, second, and third-generation biofuel technologies (Ramos et al., 2022; Weber et al., 2020).

Recycling and waste management are key pillars of the environmental dimension of the CE in LAC because they can significantly reduce emissions and environmental impacts compared to landfill disposal, which is predominantly used in the region (Li et al., 2022). Additionally, recycling helps to minimise the extraction of virgin materials, thus conserving natural resources (Li et al., 2022; Molina and Pascua, 2022), which can be complemented by energy savings and the production of energy from residual materials (Maria et al., 2023). For example, in Brazil, using wood waste from the timber industry for construction purposes can promote a CE through "cascading wood" (Caldas et al., 2021). The use of residual wood significantly reduces life-cycle GHG emissions, especially when used instead of virgin materials (Caldas et al., 2021). Going even further, biological and innovative recycling technologies can improve energy efficiency and support economic recovery. For example, in Mexico, biodiesel production from black soldier fly larvae could dramatically reduce CO_2 emissions by 86 % (Aguilar-Murguía et al., 2022). Finally, the energy recovery of MSW can optimise transport logistics and extend the lifespan of landfills (Devendran et al., 2023) and also contribute to broader economic and social aspects, like enhancing energy security (Caldas et al., 2021; Cervantes, 2021), waste incineration and methane capture (Pablo Emilio et al., 2022) and bioelectricity from sugarcane (Oliveira Pavan et al., 2021).

3.2. Barriers

While the opportunities and drivers for adopting a CE in LAC are compelling, addressing the significant barriers that make this transition difficult is essential. Despite the promising prospects, various challenges, such as regulatory hurdles, financial constraints, and technological gaps, pose substantial obstacles. Understanding these barriers is crucial for developing effective strategies and policies that can facilitate a smoother and more efficient shift towards a circular economy. The main barriers, which mostly encompass weaknesses and threats, are summarised in Table 2 (see Table S4 in SI for the literature references) and further discussed in the subsections hereafter.

3.2.1. Political

Underdeveloped sorting and collection systems are among the biggest political challenges for a CE in LAC. Politically motivated barriers include urban planning aspects (Deus et al., 2022) and suboptimal location of collection and sorting centres (de Oliveira et al., 2019; Kutralam-Muniasamy et al., 2023). The slow development is influenced by high costs for small collection amounts (Barquete et al., 2022; Ferronato et al., 2022b; Neto et al., 2023) (see section 3.2.2), as well as the lack of consumer awareness on waste management (Duarte Castro et al., 2022; Ferronato et al., 2023b; Parodi et al., 2022) (see section 3.2.3), all of which can derive from a lack of political engagement. The informality (and illegality of some activities) of the sector (Brito et al., 2022), along with the lack of regulation (Duarte Castro et al., 2021), also contribute to its suboptimality and lagged development compared to other regions in the world (e.g., the European Union). Similarly, insufficient governmental incentives for companies to transition to more circular operations (Cortez et al., 2022; Maria et al., 2023; Oliveira Silva and Morais, 2021) permeate the establishment of operational activities that can support the transition to a CE, such as waste collection and management (Deus et al., 2022; Parodi et al., 2022), and reverse logistics (de Lorena Diniz Chaves et al., 2021). However, the lack of incentives also reaches coordination actions (Oliveira et al., 2018), sectoral agreements (de Lorena Diniz Chaves et al., 2021), as well as research, development, and innovation (Nadaleti et al., 2020), and education for behavioural change (Gutberlet and Uddin, 2017; Lima et al., 2021). There is a deficiency in robust political frameworks that would incentivise circularity, coupled with a lack of specific details on CE strategies and procedural governance issues, particularly concerning landscapes and resource use (Bastos Lima, 2022; Chiappetta Jabbour et al., 2020). One example is the lack of support for industrial symbiosis, exploring technical solutions and legal compliance. Unsurprisingly, there is also a lack of disincentives for harmful practices (Aguiñaga et al., 2018; Chaves et al., 2022), which is coupled with the absence of financial incentives, subsidies, and educational programs (see section 3.2.3).

The informal waste sector in LAC is large (Martínez, 2021) and unstructured (Ferronato et al., 2018), with scarce numbers of waste picker associations (Fidelis et al., 2023). There is low support both from the government (Ferronato et al., 2019a; Korsunova et al., 2022) and the private sector (Guarnieri et al., 2020) to acknowledge the crucial role of waste pickers in a CE (Xavier et al., 2021). The high informality can be attributed to the above-mentioned limited support and lack of political willingness to recognise waste pickers as well as the challenging economic conditions in some LAC countries. Also, formal recyclers do not usually work with hand pickers (Botelho Junior et al., 2024), even though waste sorting is commonly done by the informal sector (Ferronato et al., 2023b; Gutierrez-Galicia et al., 2022). This limited governmental support and lack of regulation, on top of incentivising informality (Guarnieri et al., 2020), leads to low-quality operations (Fuss et al., 2021).

When it comes to the standardisation of activities and ensuring compliance with environmentally safe operations, there is a lack of enforcement of rules and procedures as environmental protection is not seen as a policy priority. Poor monitoring capabilities can result in a lack of control of industry performance (Aguilar et al., 2022) and an absence of punitive measures for any harm caused (Aguiñaga et al., 2018), such as inadequate handling of waste with the consequent environmental contamination (Ferronato et al., 2019a). This is underpinned by a lack of infrastructure for such monitoring (López-Pacheco et al., 2021) (see section 3.2.4), driven by a lack of economic power and political

Table 2
Barriers to achieving a circular economy in Latin America and the Caribbean.

Dimension	Barrier
Political	Lack of governmental incentives and support to increase resource efficiency Limited support to waste pickers Lack of enforcement, monitoring control, and impunity for non-compliance with environmental regulation Excess of bureaucracy
Economic	Lack of techno-economic analysis Economic growth linked to increased consumption and waste Absence of formal valorisation markets Low value and no demand for secondary materials High costs of recycling processes and technology improvements Scaling challenges Difficulty in measuring financial benefits and profitability of the circular economy Industry resistance to eco-friendly practices due to cost concerns Lack of market presence and consumer demand Lack of economic instruments to discourage final disposal and promote waste recovery
Social	Lack of awareness about the concept and benefits of the circular economy Lack of environmental education initiatives and skilled professionals, alongside the significant expenses associated with personnel training Insufficient stakeholder cooperation schemes The undervaluation of informal workers involved in sorting and collection tasks Inefficient communication
Technological	The circular economy is still in the early stages in the region Lack of understanding of circular economy technical practices Underdeveloped sorting and collection systems Lack of circular design Lack of adequate infrastructure and information Low level of readiness of locally available technology and dependence on imports Lack of interconnection with other technological tools Lack of data and indicators to monitor performance
Legal	Lack of regulation and regulatory frameworks for solid waste, electrical and electronic waste, and mining-environmental practices Inefficient handling of end-of-life products in the black market, leading to illegal activities Recent and insufficiently implemented regulations and actions towards recycling Lack of laws incentivising circularity and specific details on circular economy strategies Import and export barriers for resource cycling
Environmental	High rate of waste generation and low recycling rates Lack of monitoring of the level of contamination of natural resources Risks of environmental contamination by the informal recycling sector Mishandling and mismanagement of hazardous wastes

willingness to acquire more technologically advanced and efficient equipment, and a lack of adequate knowledge leading to ill implemented initiatives (Guarnieri et al., 2020). Moreover, when illegal activities take place, such as setting up illegal dumpsites (Segura-Salazar and Tavares, 2021) as well as dismantling sites (Soares et al., 2023), there is an absence of legal-administrative penalties that can be implemented by the government to be borne by the responsible parties (Dias et al., 2022).

The establishment of reverse logistics and other necessary activities (e.g., sectoral agreements, technology availability, etc.), to both operationalise CE strategies (Oliveira Silva and Morais, 2021) and to define responsibilities (Guarnieri et al., 2020), are costly and difficult to pursue without governmental support. Thus, there are scarce public initiatives to create disincentives to linear practices and final disposal (Rondón Toro et al., 2023) and to incentivise the recovery of materials (de Lorena Diniz Chaves et al., 2021; Del Borghi et al., 2022). This lack of initiatives, coupled with the incipient regulation, makes illegal activities common (Brito et al., 2022).

Therefore, the absence of clear political willingness results in a lack of legislation, enforcement, and integration of informal activities, making the transition to a CE difficult in the region. When regulations exist, and there are standards to be followed, such as the National Policy on Solid Waste (PNRS) in Brazil, insufficient cooperation schemes among the public and private stakeholders hinder reaping greater benefits, which often relates to barriers on a social dimension (see section 3.2.3). In LAC, the pitfalls around collaboration also often stem from the excess of bureaucracy. Overwhelming bureaucracy harms the implementation of new initiatives and challenges interested parties' willingness (Fuss et al., 2021). Bureaucracy also limits transparency and access to information on environmental performance (Aguilar et al., 2022) (see section 3.2.6), slows innovation and technological development (de Moraes et al., 2023), disrupts the obtention of resources (causing delays) (Ferrari et al., 2023), and weakens the possibility of implementing public policies (Bijos et al., 2022).

3.2.2. Economic

The transition to a CE in LAC faces significant economic challenges. A primary challenge stems from the entrenched connection between economic growth and increased material consumption, which fuels the region's waste generation cycle. As economies expand, so does consumer demand, leading to higher production rates and, consequently, more waste (Botelho Junior et al., 2024; Fidelis et al., 2023).

Another major problem is that the region lacks formal markets for material recovery (Ferronato et al., 2023b; Guarnieri et al., 2020; Lara-Topete et al., 2023). The main challenge is the economic structures prevalent in the region, which prioritise for-profit growth over environmental or social sustainability considerations (Rondón Toro et al., 2023). One example is the low value and no demand for recovered materials (such as steel, plastics, and aluminium) (Brito et al., 2022; Carvalho Machado and Kindl Da Cunha, 2022). The scarcity of a skilled workforce for new waste management models also represents a relevant barrier (see section 3.2.3.). De Moraes et al. (2023) state that human capital, specifically technical and soft skills, matters only when there is access to financial resources.

Another barrier that nurtures the lack of circular markets is the high costs of secondary materials, which are attributed to several factors, such as the poor culture in using recycled components, the elevated costs of formal recycling processes (Rodrigues et al., 2021; Silva et al., 2022), and the challenges in the process upscaling (Fuss et al., 2021; Ribeiro et al., 2016) at the region (Reis Neto, 2021) and national level (Guarnieri et al., 2020). In addition, the lack of environmental education (see section 3.2.3.) is translated into low sales of recycled products due to negative perceptions of quality and durability. For example, during the initial stages of an ecological tiles business in Brazil, manufacturers faced challenges in entering the tile market because recycled products were perceived as "low quality" and "non-durable" (Barquete et al., 2022).

The combination of high costs associated with the implementation of new CE practices and technology improvements (Rodríguez-González et al., 2022) and the lack of economic instruments to discourage final disposal and promote waste recovery (Barquete et al., 2022) constraint the development of CE solutions in the region. These elevated costs include research and development investment and acquiring new equipment and infrastructure, which in most cases is imported (Cezarino et al., 2019; Ferronato et al., 2022b; Tabelin et al., 2021), for instance, electrical and electronic equipment (Leitão et al., 2023). Finally, insufficient data for informed decision-making (see section 3.2.4.) also accentuates the economic challenges (Basnak and Giesen, 2023; de Andrade Junior et al., 2017; Fidelis et al., 2023), mainly in informal activities (Gutberlet and Uddin, 2017) which causes an industry resistance to adopt eco-friendly practices (Rodríguez-González et al., 2022). This is accentuated by the lack of comprehensive techno-economic analysis to evaluate the cost-benefits of deploying CE strategies in LAC (López-Sánchez et al., 2023; Rodríguez-González et al., 2022; Tedesco et al., 2022). Accordingly, the effective application of CE strategies is scarce (Bijos et al., 2022; Guarnieri et al., 2023), especially among SMEs (Rodríguez-Espíndola et al., 2022). This is true not only in terms of economic aspects but also in operational activities and partnerships (Faria et al., 2023), awareness, commitments, and regulations, which are non-existent or under formulation (Dziedzic et al., 2022).

3.2.3. Social

One of the main obstacles to the transition to a CE in LAC is that the general public has scarce or no knowledge, or scepticism, about the real benefits behind the implementation of CE solutions, including selective waste collection and recycling (Lara-Topete et al., 2022). The general public lacks awareness regarding the fate of waste and the individuals involved in its management. For example, in a recycling context, a large portion of Brazilian society (59 %) is unaware of the usefulness of recycling processes and the individuals involved in it (de Oliveira et al., 2019). Moreover, approximately 81 % of Brazilians have little to no knowledge about the existence of recyclable waste collector associations (de Oliveira et al., 2019). As a result, people prefer not to *"waste their time"* by separating their wastes if *"everything is going to end up together in the same truck or landfill"* (Ferronato et al., 2022a). This attitude barrier is a consequence of the population's lack of environmental communication and education. Without active participation from the population in waste separation, efforts to recycle and recover valuable materials are much less effective, even if the infrastructure exists.

Another social barrier is the environmental education deficiency due to inadequate practical curricula, caused mainly by a lack of economic resources (Ferronato et al., 2022b). The low quality of basic education is reflected in the population's limited understanding of sustainability and its advantages (Barquete et al., 2022). Yet, there is an uncovered demand for professionals with the knowledge to integrate CE principles into production processes, considering developing countries' specific needs and circumstances (Ferronato et al., 2022b). Even though there is a demand for these types of sustainability-minded professionals, the high cost of training personnel is still a barrier (de Moraes et al., 2023; Magnusson et al., 2022; Rodríguez-González et al., 2022). These two barriers (lack of education and unmet demand for professionals) keep the population, including the industry sector, in a vicious cycle of not practising a CE due to the lack of knowledge. Until society is sensitised, it will be very challenging for the CE to become mainstream (Da Silva, 2018).

The analysed studies stress the need for trusted and productive partnerships in LAC, and the involvement of all supply chain members for the effective implementation of a CE. This implies public, private, formal and informal sectors, non-governmental organisations (NGOs), academia and the general public. However, there is a crucial link in the chain that needs to be considered in LAC, which is waste pickers, who play a crucial role in waste management by recovering recyclable materials and promoting sustainable practices (Fuss et al., 2021; Moraes et al., 2023). For example, approximately 20 million people in Mexico are engaged in informal waste collection activities, collecting 70 % of the total solid waste and providing their services to areas lacking formal waste management services (Fidelis et al., 2023). Despite their importance, waste pickers have been marginalised in society due to a lack of recognition of their labour, precarious working conditions, social stigma, and institutional exclusion (Duarte Castro et al., 2022). Many waste pickers face challenges entering the formal labour market, often due to low education levels. This impacts directly on workers' income and operational efficiency. To address these challenges, it is necessary to ensure working conditions by integrating them into formal labour structures.

Finally, improved communication and understanding of the CE among supply chain actors is needed. For example, a lack of coordination is identified as a major obstacle to promoting CE strategies in the agricultural sector in Argentina, specifically the poor communication of the public administration with the rest of the stakeholders (Rótolo et al., 2022). In Colombia, the lack of coordination and fragmentation among stakeholders throughout the value chain made the development of circular strategies very challenging in the construction sector in Valle del Cauca (Maury-Ramírez et al., 2022). These cooperation problems occur between international, national, and/or local actors (Ferronato et al., 2022a; Ribeiro Siman et al., 2020), who have different levels of commitment. This outlines the low engagement (Ferronato et al., 2020a; Oliveira Silva and Morais, 2021) of both governmental and private stakeholders in LAC (de Lorena Diniz Chaves et al., 2021) (see section 3.2.1.), which is often a barrier to maintaining the continuity of industrial and territorial projects (Faria et al., 2023). Through clear communication, actors can align their efforts, optimise resource utilisation, and foster innovation for sustainable and circular business models (Aguiñaga et al., 2018).

3.2.4. Technological

The bottom line of many of the technological barriers to a successful CE in LAC is related to a lack of understanding of CE practices. A limited understanding of these practices, in terms of what they entail and the benefits they might bring, coupled with a low level of technological readiness contribute to lagged technological advancement in the region.

The lack of adequate infrastructure to support circular practices is mostly hampering efficient waste management and recycling systems (Bijos et al., 2022). The underdeveloped sorting and collection systems underpin the low recycling rates observed in LAC (Deus et al., 2022; Maria et al., 2023), which are influenced by: i) high transportation distances (Molinos-Senante et al., 2022); ii) limited infrastructure (Pimentel Pincelli et al., 2021); iii) stakeholders not having their role specifically included in laws and discussions(Bernardes et al., 2024); iv) no targets for recycling (Duarte Castro et al., 2021); and v) poor compensation of both the formal (Bernardes et al., 2024) and informal (Ferronato et al., 2022b) employees working on recycling. Once the infrastructure is available, another barrier is the lack of technological knowledge to, for instance, replace single components in a product that needs repair or recovery of the different materials in alloys (Bijos et al., 2022; Duarte Castro et al., 2021).

The implementation of circularity indicators is also crucial to the transition to a CE because only what is measured can be managed (Barros et al., 2023). In this regard, some key data for the CE transition in LAC are missing (Ferronato et al., 2019a; Molinos-Senante et al., 2022) including: i) information on waste management costs (Ferronato et al., 2023a); ii) qualitative and quantitative data on pollution (Soares et al., 2023), iii) quality specifications of recoverable materials (Lara-Topete et al., 2022); and iv) data on the demand for resources (Soares de Carvalho et al., 2022). The limitation on data availability also embeds the lack of technologies enabling data transmission, such as those with monitoring purposes (Guarnieri et al., 2020). Furthermore, available data from waste generation, collection and recycling is not widely shared (Aguilar et al., 2022) or even reliable (Dias et al., 2022; Ferronato et al., 2018). This data can be difficult to integrate into different systems because it might have been produced with different purposes and under different methodologies (Bijos et al., 2022). Notwithstanding, in the efforts to initiate proper monitoring and reporting, this lack of data might lead to the use of average data (e.g., to make assumptions or for reporting) that is not locally relevant (Duarte Castro et al., 2021).

3.2.5. Legal

Legal barriers highlighted by scholars are legal uncertainties and ambiguities in interpreting legislation stemming from a lack of strong political frameworks (e.g., section 3.2.1) (de Lorena Diniz Chaves et al., 2021; Sellitto and Almeida, 2020). Additionally, there is a noticeable absence or minimal integration of CE principles within existing standards and legislation, such as in the area of mining waste (Lemos et al., 2023). Furthermore, most of the existing CE regulations in the region are not fully implemented and are technically insufficient, leading to a confusing regulatory landscape (Deus et al., 2022; Mühl and de Oliveira, 2022). When regulations do exist, they lack clear strategies (Coelho and Diaz-Chavez, 2020), are new and evolving (Ferronato et al., 2023a), or need to be customised for the LAC context (Soares et al., 2023). This leads to low recycling rates and negative consequences on both the formal and the informal sectors (Ceglia et al., 2016; Rondón Toro et al., 2023). Lack of or inadequate regulation also triggers informality (Ferronato et al., 2019b), which contributes to imbalances in socioeconomic aspects, such as income, work safety, and quality of life of informal workers (Fidelis et al., 2023; Lara-Topete et al., 2022).

Another legal challenge is the lack of comprehensive regulations and regulatory frameworks specifically tailored to manage key types of waste in LAC (e.g., MSW, WEEE, mining) (Cruz Reina et al., 2023); for instance, mining waste (Li et al., 2022; Méndez et al., 2022), WEEE (Neto et al., 2023), municipal solid waste (Rondón Toro et al., 2023). Moreover, the lack of legislation on the import and export for resource cycling (Braz and de Mello, 2023) creates a shifting burden between countries in terms of transferring the environmental impacts between countries' trade. The absence of clear guidelines and legal provisions for these key areas creates uncertainty. It hinders the adoption of sustainable practices, allowing for the illegal handling of end-of-life products, such as dismantling cars in the black market (Neto et al., 2023; Soares et al., 2023).

3.2.6. Environmental

Environmental impacts (e.g., climate change, ozone layer depletion, atmospheric pollution, extinction of natural species, acid rain, desertification and runoff of leachates) (Díaz-Peña and Tinoco-Castrejón, 2019) are on the rise in LAC due to a shortage of financial resources, regulations, appropriate technologies, political will, public awareness, and know-how (Ferronato, 2021). These barriers prevent the implementation of CE strategies, and combined with the high rate of waste generation and low recycling rates (Pegels et al., 2022; Sulis et al., 2021; Xavier et al., 2021), lead to a large amount of waste going to landfills or open dumps and contributing to environmental risks and impacts (Chiappetta Jabbour et al., 2020; Lima et al., 2021).

In addition to the technological challenges (see section 3.2.4), there is a high uncertainty in LAC countries regarding the environmental sustainability of emerging waste treatment technologies. While the goal is to manage waste, there is no evaluation of these technologies' energy, resource efficiency, emissions, and long-term environmental impact. This limitation is accompanied by the general lack of track of pollution levels and control of compliance with environmental standards (Duarte Castro et al., 2021; Guarnieri et al., 2020; Lara-Topete et al., 2022).

Finally, one of the causes of environmental contamination in the region is the informal recycling sector because, although they contribute to material recycling, their mishandling and mismanagement of hazardous wastes can lead to environmental impacts (Ferronato, 2021; Ferronato et al., 2020b; Hernandez-Jimenez et al., 2022). There is a need to formalise the informal sectors involved in waste collection and sorting in developing countries (Ferronato et al., 2023b) (see sections 3.2.1. and 3.2.3) and implement CE strategies such as repair markets, refurbishing, trade of second-hand products, and recycling chains. Easy, cheap, and profitable end-of-life routes must be adopted to overcome environmental risks such as the overloading of water and soil ecosystem (Piedra-Jimenez et al., 2022; Segura-Salazar and Tavares, 2021; Vega-Quezada et al., 2017).

3.3. Circular economy strategies

In the last few decades, different CE strategies have been implemented depending on the waste feedstock resources, the final product and coproducts, and the technology used. The four key strategies within the CE framework are often described as closing, slowing, narrowing, and regenerating. Closing focuses on creating closed-loop systems where products and materials are recycled and reused creating new value, thereby minimising the amount of waste sent to landfills (Velasco-Muñoz et al., 2021). Narrowing focuses on using fewer resources per product to improve efficiency and reduce waste (Bocken et al., 2015). Slowing aims to extend the utilisation period of products through the design of long-life goods and product-life extension strategies such as maintenance and repair to slow down the flow of resources (Bocken et al., 2015). Regenerating, in turn, goes beyond simply minimising negative impacts, it includes all actions to preserve and enhance natural capital (Velasco-Muñoz et al., 2021).

Due to the extensive scope of this literature review, not all articles were eligible to be assigned a CE strategy; this depended on the approach of each article. Therefore, 205 out of 247 articles analysed in this review were considered for this section. It is worth noting that several articles were also assigned more than one strategy. Considering the frequency of categories assigned to articles in terms of their relation with the CE, closing was the most utilised strategy (53 %), followed by slowing (26 %), narrowing (15 %), and regenerating (6 %).

Most studies seemed to emphasise the importance of closing material and energy cycles to achieve a more circular system chasing an efficient use of resources (e.g., Barquete et al., 2022; Brito et al., 2022; Montoro et al., 2019) and cleaner production (e.g., Amorim Júnior et al., 2021; Nadaleti et al., 2021a; Santos et al., 2020). Considering that CE in LAC is in its infancy, it is reasonable that the main strategy used is closing, since it is the "easier" strategy to pursue (Bocken et al., 2022). The prevalence of the closing strategy in this analysis can be attributed to several region-specific factors, such as significant challenges in waste management, with issues of open landfills and the need to adopt more sustainable practices (e.g., Aguilar et al., 2022; Deus et al., 2022; Devendran et al., 2023). Adopting closing strategies, such as recycling and reuse, reflects the urgency to address these problems. Furthermore, LAC often faces constraints in terms of economic and technological resources (sections 3.2.2 and 3.2.4, respectively). Through material recovery and reuse, closing cycles can represent a practical and economically viable solution to maximise available resources. In addition, increasing environmental awareness, combined with implementing regulations in some countries in the region, has led to an increase in the adoption of CE practices to meet environmental and sustainability standards (section 3.1.6). Finally, implementing closing strategies not only addresses environmental issues but can also have economic and social benefits in the region such as the creation of business opportunities (Faria et al., 2023; Sant' Ana et al., 2023; Vargas-Terranova et al., 2022) and jobs (e.g., Brito et al., 2022; Galatti and Baruque-Ramos, 2022; Mohammadi et al., 2021).

The next two strategies considered in the analysed studies were slowing and narrowing. Several studies focused on the optimisation of limited resources since LAC faces significant challenges in terms of financial, technological, and infrastructure resources (sections 3.2.2 and 3.2.4). Under these conditions, actions that allow doing more with less are useful, such as the valorisation of wastes from agriculture and fishing activities (Cornejo-Ponce et al., 2020; Rojas Herrera et al., 2023) or increasing efficiency and savings in energy consumption in a dairy factory (Font Prieur and López Bastida, 2023). Another driver for these types of strategies is finding solutions to the management of particularly challenging waste in the region, like EEE (Leitão et al., 2023; Uriarte-Ruiz, 2022), or textile products (Jarpa et al., 2021; Rossi et al., 2020).

The least utilised strategy is "regenerating". The implementation of regeneration strategies requires significant efforts at financial, human, and technological levels (e.g., Aguiñaga et al., 2018; de Moraes et al., 2023; de Souza and Pacca, 2021). Therefore, in the LAC context of limited resources, studies opt for more pragmatic and cost-effective strategies and focus on technical and operational aspects of waste management (e.g., recycling efficiency and selective collection) and minimising environmental impacts. Finally, this trend may evolve in the future as awareness, understanding, and resource availability change in the region.

3.4. R's strategies

A common approach to summarising CE strategies is the R's strategies. The ten R's (Kirchherr et al., 2017; Potting et al., 2017; RLI, 2015) are aligned with CE strategies defined in section 3.3 and encompass: smarter product use and manufacture (narrowing; refuse, rethink, reduce), expand product lifespan and its parts (slowing; reuse, repair, refurbish, remanufacture, repurpose) and useful application of materials (closing; recycle and recover). The prominence of each of these strategies in the reviewed studies is illustrated in Fig. 3 and discussed hereafter (see Table S5 in SI for the literature references).

3.4.1. Smarter product use and manufacture: Refuse, rethink and reduce

Refusing comprises making a product redundant by abandoning its function or by offering the same function with a radically different product (Kirchherr et al., 2017; Potting et al., 2017). Refuse strategies were mentioned in eight articles. An example of the implementation of this strategy in LAC is fossil fuels being replaced with refuse-derived fuel (RDF) (Chaves et al., 2022; de Lorena Diniz Chaves et al., 2021), which is the combustible fraction of MSW and is mainly consumed in the cement industry (Ferronato et al., 2019b; Guimarães Filho et al., 2023). In this sense, de Lorena Diniz Chaves et al. (2021) show that RDF has high calorific power, lower levels of hazardous components, and is a more homogeneous material compared to the original option (fossil fuels). The potential implementation of reverse logistics systems is essential for the use of waste in the production of RDF.

Rethinking involves a thorough reevaluation of values and actions taken to make more intense use of resources for instance, by sharing products (Kirchherr et al., 2017; Potting et al., 2017). Rethinking implies that some practices may go under reconsideration, potentially causing changes in individual behaviours or within the system itself. Some studies in LAC (18 articles in the portfolio) suggest that it is necessary to rethink habits, practices and systems to promote more significant changes towards CE (e.g., Aguilar-Murguía et al., 2022; Nadaleti et al., 2021a; Sehnem et al., 2019). Rethinking and advocating for changing habits in LAC leads to benefits such as reduction of waste and CO_2 emissions (see, e.g., Del Borghi et al., 2022; Maciel-Silva et al., 2021; Sehnem et al., 2022).

Reducing involves increasing efficiency by, for example, minimising the consumption of raw materials and/or decreasing waste generation (Kirchherr et al., 2017; Potting et al., 2017). Reduce can also involve increasing efficiency in product manufacture or use by consuming fewer natural resources. This strategy is one of the most prevalent and frequently addressed in the reviewed studies (46 articles). An important example in LAC is sugarcane, which can become a solution to reduce GHG emissions in several countries of the region (Vandenberghe et al., 2022). Ethanol produced from sugar cane can be used as biofuel in vehicles, partially or completely replacing gasoline. Additionally, sugarcane plantations can capture atmospheric carbon during their growth cycle, helping to remove CO_2 from the atmosphere and store it in plant

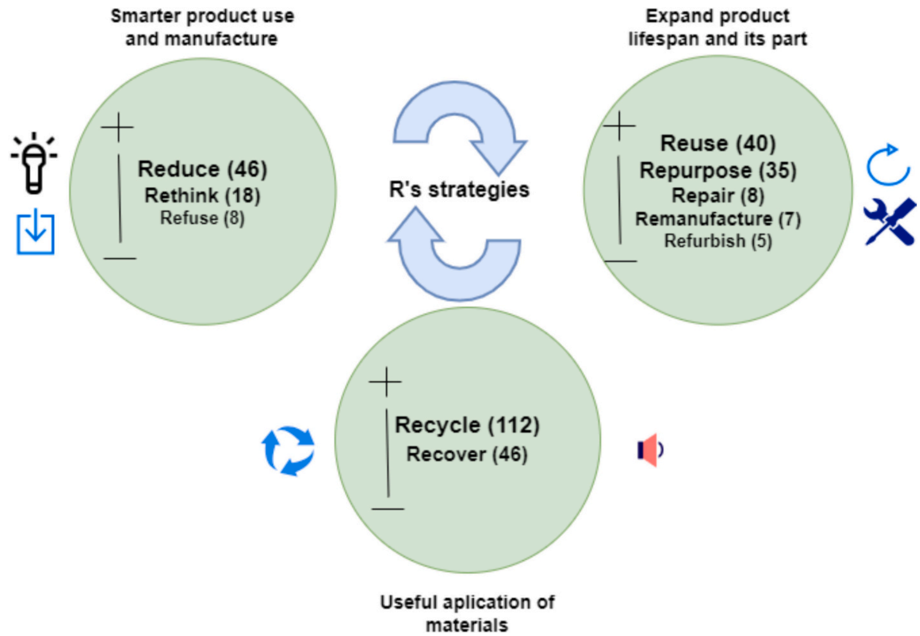

Fig. 3. Prominence of ten R's strategies in Latin America and the Caribbean. The font size of the R's is proportional to the number (in parenthesis) of articles for each R. The total number is 325 because several of the 247 articles consider two or more R's.

biomass and soil. Furthermore, sugar cane can also be used in the production of bioplastics and other renewable materials, replacing materials of fossil origin. Another example is the application of organic waste materials to agricultural soils, which can enhance nutrient cycling and soil fertility, reduce reliance on synthetic fertilisers, and alleviate agricultural costs (Fink et al., 2021). In another example related to the agrifood sector, the negative impacts on the production of Cumanayagua cheese in Cuba were reduced after the application of CE practices in terms of energy consumption, extending the useful life of products, and reusing waste (Font Prieur and López Bastida, 2023). In the textile sector, "fast fashion" has critically increased the amount of clothing produced and discarded (European Parliament, 2020) and has become an increasing environmental concern in the region, with areas like the Atacama Desert (Chile) becoming open dumps for discarded clothes (Sánchez De Jaegher, 2024). Embracing circular fashion practices can lead to cleaner production methods and reduce textile waste (de Aguiar Hugo et al., 2023).

3.4.2. *Expand product lifespan and its part: Reuse, repair, refurbish, remanufacture, repurpose*

Reusing addresses the use of a resource or product once again, fulfilling its original function, and giving it a new cycle (Kirchherr et al., 2017; Potting et al., 2017). It also encompasses the reuse of a discarded product, which is still in good condition and fulfils its original function, by another consumer, thereby contributing to slowing the loop by extending the product's lifespan. For example, Uriarte-Ruiz (2022) explored the potential incentives to create a CE of mobile phone replacement and reuse in Greater Mexico City, including i) establishing safe public transport; ii) increasing the incentives to recycle, repair, or exchange phones; iii) providing affordable mobile contracts and insurance and longer replacement cycles for contract users; and iv) facilitating regularised markets for second phones and software updates for older devices. One of the potential benefits of waste reuse is that it will avoid end-of-life impacts, which is crucial because waste treatment is one of the main environmental and health challenges in LAC. Finally, the urban solid waste management (USWM)-index, an index to evaluate waste management in urban areas was applied in four cities in Brazil (Moraes et al., 2023). Despite complying with national solid waste policy requirements, the management systems of these four cities were inefficient in promoting reuse and other R's like reducing. This conclusion reinforces the lack of waste treatment regulations in many LAC countries that implement CE principles before the end of life (landfilling or incineration) or recycling (section 3.2.5.).

Repairing entails conducting corrective operations to repair or fix a product to restore it so it can perform its intended function once again (Kirchherr et al., 2017; Potting et al., 2017). This strategy is among the less studied in LAC (only eight articles), probably because repair still is an activity mainly handled by the informal sector in LAC (Camargo, 2012) and formal companies still need to improve on their handling of end-of-life products to be able to realise strategies such as repair ((Rodríguez-González et al., 2022). According to the reviewed studies, repair research in LAC has focused on industry 4.0 technologies to produce highly mechanised and automated goods (Lasi et al., 2014; Lopes de Sousa et al., 2022) and on the EEE sector (Leitão et al., 2023), particularly mobile phones (Uriarte-Ruiz, 2022). The relationship between repair and Industry 4.0 is mainly linked to the way technology is being integrated into industrial repair and maintenance processes, where, for example, products are upgraded and maintenance services are offered (Lopes de Sousa et al., 2022), especially in the case of EEE. Repair in the textile industry has also been studied in LAC, more specifically, Jarpa et al. (2021) highlight the positive effects of companies offering clients the option to repair old textile products or free clothing repair services to extend the product life in Chile.

Refurbishing is updating or restoring a product and bringing it up to date, especially with regard to its aesthetic characteristics (Kirchherr et al., 2017; Potting et al., 2017). Even though only five articles addressed refurbishing in LAC, this strategy is commonly used within the construction sector with the refurbishment of urban buildings (Del Borghi et al., 2022). The construction sector is crucial in LAC, one of the most urbanised regions of the world (UN-DESA, 2018). Refurbishing is also observed in the energy industry, in the updating of photovoltaic systems and modules in Mexico, being the solar sector key for the transition to a low-carbon energy mix in the whole region (Santoyo-Castelazo et al., 2021). Another prominent sector where refurbishing is observed is mobile phones (Uriarte-Ruiz, 2022), where refurbishing can help extend the life of such devices of highly-paced use in Mexico.

Remanufacturing (also named reverse manufacturing) entails reprocessing parts (or the whole) of a recovered product to make a new one (Kirchherr et al., 2017; Potting et al., 2017). This approach uses parts of discarded products in a new product with the same function. Only seven articles have addressed this strategy. Remanufacturing has been investigated more intensively within the WEEE sector, which is key for LAC, as 1.5 million tons of such waste are produced annually only in Brazil (Ottoni et al., 2020). This waste generation leads to losses related to opportunity costs, for instance, within the electric vehicle (ELV) management system, as new markets for remanufactured products could instead provide financial gains (Soares et al., 2023). In this sense, regulations, such as the National Policy of Solid Waste in Brazil, have started to stimulate remanufacturing from WEEE (Brito et al., 2022). Another industry where remanufacturing has been an active strategy in the whole region is the automobile sector (Rodríguez-González et al., 2022). Significant efforts have been directed at decreasing costs related to remanufacturing in this industry in LAC, by, for instance, making use of sustainable supply chain management (SSCM) practices to investigate new alternatives in the remanufacturing of lithium-ion batteries (Duarte Castro et al., 2021; Rodríguez-González et al., 2022).

Repurposing refers to using parts of discarded products in a new product with a different function (Kirchherr et al., 2017; Potting et al., 2017). Repurposing is quite a common strategy in LAC (35 articles) and can be observed in many industries. In the case of the bioeconomy, biomass waste has been repurposed, for example, for the removal of toxic metals from a range of mediums (Ribeiro et al., 2021; Valdés-Rodríguez et al., 2022), as a soil amendment (Parodi et al., 2022), fertiliser (Amorim Júnior et al., 2021), and biofuel (Gutiérrez et al., 2021; Mühl and de Oliveira, 2022; Ramos et al., 2022); for instance from food waste (Weber et al., 2020) and forest waste (Piedra-Jimenez et al., 2022), or packaging material (Ribeiro et al., 2021). Other biomass materials that are not waste have also been repurposed to produce phenolic antioxidants (de Souza Silva et al., 2021), health-enhancing products (pharmaceuticals and functional foods) (Benvenutti et al., 2021), and ingredients for food products (Rodríguez-Ramos et al., 2022). Moreover, biosolids from anaerobic sewage sludge (Cristina et al., 2020), aquaculture systems (Cornejo-Ponce et al., 2020), and wastewater treatment systems (Avellán et al., 2022) have been repurposed for use in fertilisation. Other potential repurposing strategies can be observed when establishing symbiosis among agricultural and livestock processes, such as composting or AD of animal waste or the sale of recently dead sheep for recovery of the skin for tanning (Cervantes, 2021). Biomass streams have also been repurposed to replace traditional materials, such as agave derivatives to replace polymers (Martínez-Herrera et al., 2021), straw products to replace insulation panels (Rojas Herrera et al., 2023), and biomass ash to replace cement (Rocha et al., 2022). Besides biomass, the repurposing of polyethylene terephthalate (PET) has been studied to produce ecological tiles (Lizarzaburu-Aguinaga et al., 2023), and the use of mining tailings has been investigated as a substitute for sand in the manufacturing of concrete blocks (Méndez et al., 2022), providing solutions to two of the most critical environmental problems (plastic and mining waste) in LAC.

3.4.3. Useful application of materials: Recycle and recover

Recycling encompasses processing materials (that have already been through one or more life cycles) into new ones with either higher or lower quality (Kirchherr et al., 2017; Potting et al., 2017), thus contributing to closing the loop by reintegrating these materials into the production cycle. Recycling spans a range of industries and materials in LAC (Rojas Herrera et al., 2023), being the R most represented in the reviewed studies (112 articles). Once again, the bioeconomy plays a crucial role, as in LAC, organic waste is recycled into construction materials for the built environment (Del Borghi et al., 2022), and used for fertilisation (Cornejo-Ponce et al., 2020) and energy purposes (Cortez et al., 2022). As observed with other R's, the textile sector is also a main focus of the existing research. The recycling of textiles can be achieved by enabling and optimising the separation of different materials for subsequent reutilisation in the production of new garments or other products (Molina and Pascua, 2022), as an alternative to the common landfilling of textiles in the region (Espinoza Pérez et al., 2022). Moreover, attention has also been given to several initiatives in the region for the recycling of different MSW fractions, like paper, plastic, and metal (de Andrade Junior et al., 2017; Díaz-Peña and Tinoco-Castrejón, 2019; Ferronato et al., 2018), as well as the establishment of policies for their recycling (Da Silva, 2018). Other outreaches of recycling within LAC include the recycling of steel (de Souza and Pacca, 2021), and copper (Li et al., 2022). Finally, Valenzuela-Levi (2019) remarks on the factors that influence municipal recycling in Chile, which can be extended to LAC. Factors with a positive influence on recycling include the existence of kerbside collection and per capita expenditure on waste management (in the case of Chile); whereas the largest negative factor seems to be the frequency of collection of waste, which discourages sorting and recycling.

Recover entails using resources for energy purposes (Kirchherr et al., 2017; Potting et al., 2017); thus, it can generally be understood as energy recovery. This is also a common strategy within LAC (46 articles). In a Brazilian context, Farrapo et al. (2023) highlight the use of briquettes from biomass waste for energy production. These briquettes are an alternative use of available biomass waste and can replace fossil/non-renewable fuels.

3.5. Guidelines, limitations and future research

This study has provided a comprehensive systematic literature review on the key drivers, barriers, opportunities and strategies for implementing circular economy initiatives in LAC. The following guidelines and recommendations are based on the main outcomes of the research and facilitate the deployment and management of a sustainable CE in LAC:

- Reinforce the development of regulations that promote CE practices beyond recycling and help businesses (e.g., through the development of new sectorial policies, incentives – especially for SMEs, assessment tools and metrics) to integrate CE solutions into their operations and innovation processes to narrowing, slowing, closing and regenerating resource loops. These new regulations should include the deployment of carbon pricing, landfill taxes and/or extended producer responsibility schemes, as well as, simplifying bureaucratic processes to facilitate the implementation of CE initiatives while improving transparency on monetary resource allocation. The alignment and harmonisation of national and local policies with international CE standards and regulations can also facilitate the integration of LAC economies into future global circular supply chains, improving the competitiveness of the region.
- Foster close collaboration and active partnerships across value chains within the same sector and from different economic sectors, including societal actors, to enhance circular practices (e.g., industrial symbiosis and reverse logistics). This includes supporting the formalisation and inclusion of informal waste workers in different value chains.
- Invest in the deployment and life cycle management of green technologies, renewable energy sources and bio-based materials. Narrowing, slowing and closing resource loops is crucial but sustainability benefits would be limited in the long term if economic systems still run on fossil-based energy and materials. The abundance and diversity of natural resources within LAC, along with favourable climatic conditions, represent an opportunity for the development of bio-industries, renewable energies, and innovative sustainable materials.
- Invest in the necessary infrastructure (e.g., facilities and logistics) for waste collection, sorting, and recycling to facilitate the transition to a territorial sustainable CE.
- Launch public awareness campaigns and educational programs on sustainable CE practices to increase understanding and support from

the general public. These campaigns should include the promotion of community-led initiatives that support local circular practices and encourage consumers to adopt sustainable consumption practices.

- Train professionals on CE practices to build a skilled workforce capable of implementing and managing successful solutions. Here, the role of schools, professional training centres and higher education institutions is pivotal to assist industry professionals, policymakers, and the general society in building human, material and economic capital.
- The support of research and development (R&D) initiatives in LAC is crucial. By fostering innovation in the above topics between LAC countries, tailored solutions that address and solve specific territorial challenges can be developed.
- Developing regional platforms for knowledge and best practices (e.g., technologies, policy approaches, experiences, etc) sharing and transfer, as well as, for collaboration on CE initiatives can help accelerate the transition across LAC countries. In this process, engaging communities in the design, planning and development of CE projects can ensure that solutions are culturally relevant and socially acceptable, increasing their chances of success. The concept of Ethical Circular Hubs, which focuses on stakeholder collaboration, ethical value chains, and social equity, can be adapted to LAC. These hubs promote innovative business models and ethical practices, addressing regional disparities and fostering inclusive growth (Garrido and Nunes, 2023).
- Finally, defining clear indicators and metrics (covering different CE and sustainability aspects) to monitor progress towards a sustainable CE is also essential. However, the lack of crucial data for the assessment and monitoring of CE strategies represents a significant limitation, as also highlighted by the Circularity Gap Report of LAC (Circle Economy Foundation, 2024).

In any case, further research should be performed to further analyse how CE policy frameworks and industry strategies, including public-private partnerships, can be implemented in different economic sectors from LAC, beyond waste management. Further studies should also focus on understanding how the development and adoption of new technologies can support the transition to a sustainable CE, especially in the context of the bioeconomy, digitalisation, Industry 4.0 and the sustainable renewable energy transition. These future studies should include how the CE deployment can contribute to improving job creation, social inclusion and the formalisation of informal sectors. Likewise, comparative studies between LAC and other regions (both in the Global South and Global North) can provide insights into the adoption and/or adaptation of best practices.

The interpretation of this study's results should take into account several potential limitations. Notably, the majority of the literature focuses on Brazil, followed by Mexico, while many countries in LAC lack sufficient studies (both theoretical and practical). This could result in a biased representation of the situation in other countries in the region, where socioeconomic and political contexts may differ significantly. Cultural, regulatory, and infrastructural differences across the region also impact the adoption of Circular Economy policies, which are not uniformly implemented. Consequently, the findings of this study might not be universally applicable throughout the region. Therefore, future research lines in the region have to focus on increasing geographical diversity (e.g., there are few articles from Central America and the Caribbean countries), but also sector variability (e.g., there is too much focus on technological aspects, particularly waste treatment) and on meso, micro and nano scales. Future efforts should also aim to integrate more comprehensive regenerative practices that extend beyond immediate recycling and waste reduction to fully exploit the benefits of a CE, fostering a more sustainable and resilient regional development. More research is also needed on repair, refuse, remanufacture, and refurbishment, because fewer than ten articles have been found for each of these R's. Finally, the comparison with similar studies of other regions could provide global insights and foster international collaboration for better implementation of CE strategies.

Another potential limitation of the study is that it relies primarily on scientific literature and does not include an in-depth analysis of the existing grey literature (e.g., industry reports) on CE and policy regulations in LAC countries, which could be extended further. Although many of the reviewed studies are grounded in each country's national CE legislation, this research does not explicitly examine how these regulatory frameworks align with or influence the progress of CE practices in the region. Future research could build on this work by incorporating a comprehensive review of current CE legislation and business case studies in LAC, exploring its impact on the implementation and success of CE strategies. Such an analysis would provide a more holistic understanding of the factors driving or hindering the transition to a circular economy and could inform both policy development and academic research in this rapidly evolving field.

4. Conclusions

A thorough systematic review of 247 articles has been conducted to comprehensively analyse the key drivers, opportunities, and challenges that shape the circular economy approach in Latin America and the Caribbean. This has been done by applying the PESTLE framework, providing a structured approach to understanding the multifaceted aspects of CE implementation in the region.

Focusing on drivers and opportunities, the results demonstrate that the transition to a CE in LAC is being driven by various aspects, including the launching of local sustainability policies, the development of technological innovations to improve energy and material, the reduction of production and consumption costs through waste reuse and recycling, as well as, the need to address relevant environmental threats in the region, such as deforestation, biodiversity loss, and high waste generation. The need to facilitate social inclusion and community development also represent key drivers for the deployment of CE strategies in LAC. From a political perspective, enhanced government initiatives recently developed in some countries have provided a new political context that supports circular practices by relying on European and Global North standards as references. Nevertheless, LAC presents unique characteristics and opportunities due to its socio-economic and environmental context.

Economically, the region's abundance and diversity of natural resources offer significant opportunities for developing bio-industries and promoting the adoption of circular practices that leverage local biodiversity. For instance, the valorisation of agricultural and agro-industrial waste and the mitigation of deforestation in the Amazon are notable particularities of LAC and priority intervention areas for the future deployment of CE initiatives. The growing public awareness in certain population sectors (particularly young and with university studies) and the advocacy for sustainability drive the demand for a CE. This trend has been accentuated by a weak regulatory framework associated with waste management in LAC and, consequently, the low technological advancement for pollution prevention and control. The need to solve these urgent challenges has driven the implementation of CE strategies, creating opportunities to minimise environmental impacts, improve community relationships, and increase employment in LAC. Due to the near absence of segregation and recycling of MSW, which mostly ends up in landfills, new legislation has only focused on improving recycling efforts, without considering other more circular strategies like, for example, reduce, reuse or repair. These recycling efforts are carried out almost exclusively by informal recyclers, who urgently need their formalisation through laws associated with the CE. Finally, the environmental imperatives of the CE, including the reduction of resource extraction and carbon emissions, align with the region's goals for environmental conservation and resilience against the impacts of climate change.

However, according to the articles reviewed, the path to a robust CE is fraught with substantial barriers. Politically, the region still suffers from a lack of support for the informal waste management sector and limited governmental incentives and policy inconsistencies in most countries, that hinder the effective implementation and continuity of CE initiatives. Economically, financial constraints and the high initial costs associated with transitioning to circular models pose significant challenges in the region, particularly for small and medium enterprises. Socially, there is a generally low level of public awareness and cultural resistance to new practices, mainly associated with a lack of environmental education and communication from the governments. These social aspects affect general consumer behaviour and the demand for recycled and sustainable products. Technologically, the region often lacks the necessary infrastructure for efficient material recycling and relies on outdated technologies that are not conducive to circular practices. Legally, weak enforcement of existing regulations and the absence of comprehensive legislation that supports all aspects of a CE impede progress. Environmentally, the lack of monitoring of industrial environmental performance and the ongoing degradation complicates the stability of circular initiatives.

Regarding CE strategies, the predominant strategy in the reviewed studies is closing, with a particular focus on recycling to reduce landfill use, addressing the immediate waste management needs of the region. Narrowing and slowing strategies, which enhance resource efficiency and product longevity, respectively, are also significant but less prevalent due to regional economic and technological constraints. Finally, the regenerating strategy is underrepresented in the studies, probably due to its higher demands for resources and investment. Regarding the ten R's, recycling (clearly associated with closing) is the strategy that has been most discussed in scientific studies and on government agendas, seconded at a considerable distance by recovery. These are the two least circular R's, indicating that the region's focus remains primarily on end-of-life strategies. However, reduce, reuse and repurpose are starting to be well represented.

CRediT authorship contribution statement

Alejandro Gallego-Schmid: Writing – review & editing, Writing – original draft, Resources, Project administration, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Camila López-Eccher:** Writing – review & editing, Writing – original draft, Visualization, Resources, Methodology, Formal analysis, Data curation, Conceptualization. **Edmundo Muñoz:** Writing – review & editing, Writing – original draft, Resources, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Rodrigo Salvador:** Writing – review & editing, Writing – original draft, Validation, Resources, Formal analysis, Data curation, Conceptualization. **Natalia A. Cano-Londoño:** Writing – review & editing, Writing – original draft, Resources, Formal analysis, Data curation, Conceptualization. **Murillo Vetroni Barros:** Writing – review & editing, Writing – original draft, Visualization, Formal analysis, Data curation, Conceptualization. **Daniel Choconta Bernal:** Writing – review & editing, Writing – original draft, Resources, Formal analysis, Data curation, Conceptualization. **Joan Manuel F. Mendoza:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Ana Nadal:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Ana Belén Guerrero:** Writing – review & editing, Writing – original draft, Validation, Resources, Methodology, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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