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Systematic Review

Circular Cities: A Systematic Literature Review of Urban Strategies for Sustainable Transitions

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Abstract

The rapid urbanization process is forcing cities to rethink their development models by adopting circular economy strategies that promote resource efficiency, regeneration, and waste reduction. This systematic literature review investigates how circular strategies are being developed and implemented to support the transition toward circular cities. Following the PRISMA guidelines, 77 studies were selected to provide a comprehensive overview of the approaches currently adopted across different urban contexts. This review identifies a four-macro-level framework encompassing urban circularity strategies, architecture and circular constructions, waste management and recycling, and food sustainability, highlighting both their interconnections and specific challenges. Results show that successful circular transitions depend on the integration of digital innovation, participatory governance, and context-sensitive policy frameworks. However, infrastructural gaps, fragmented regulations, and limited citizen engagement continue to hinder progress. Overall, this review highlights the need for integrated strategies that connect environmental, institutional, and social dimensions to foster more circular, resilient, and inclusive urban systems. These findings contribute to the growing understanding of how cities can operationalize circular economy principles to address sustainability challenges and accelerate the transition toward regenerative urban development.

Keywords: circular economy; circular cities; food management; waste management; circular architecture

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1. Introduction

The concept of circular economy (CE) has its roots in disciplines such as industrial ecology, environmental and ecological management, sustainable business economics, and other branches related to sustainability [1]. The term "circular economy" was formally used for the first time by David Pearce and Kerry Turner in their 1990 book Economics of Natural Resources and the Environment [2] and represents a sustainable alternative to the linear "take–make–dispose" approach. This approach promotes resource efficiency through strategies such as reuse, recycling, refurbishment, and repair, creating closed systems where materials are continuously reintegrated into production processes [3,4].

In recent years, attention has shifted from industrial applications to urban systems, giving rise to the notion of the "circular city". Cities are now seen as complex ecosystems where resources flow and materials, energy, water, and nutrients can be redesigned to create closed-loop, regenerative processes.

With accelerating urbanization, circular cities have become a central topic in academic and policy debates. However, despite growing interest, cities face the challenge of clearly defining the CE from an urban perspective, as they are dynamic and complex systems [5].

Global urbanization presents striking figures: the urban population increased from 14% in 1990 to 54% in 2015, with projections to reach 66% by 2050 [6]. Despite covering less than 2% of the surface of the Earth, cities consume between 60% and 80% of global natural resources [7]. This rapid urbanization entails significant challenges such as (1) the increase in global greenhouse gas emissions: cities produce approximately 70% of global CO_2 emissions, with an expected annual increase of 2–3% [8]; (2) an increase in noise pollution, where noise averages 72.9 dB (A), compared to 53.3 dB (A) in residential areas [9]; (3) growing pressure on water supply, with projections of an 8% increase in vulnerable urban areas by 2040 [10]; and (4) a significant rise in waste production, which currently accounts for around 50% of global waste [7]. As urban areas account for over 70% of resource consumption and greenhouse gas emissions, they hold both the responsibility and the potential to accelerate the transition toward more sustainable systems.

In this context, the CE has emerged as a compelling alternative to the dominant linear economic model. Implementing the CE in cities could bring significant benefits, including a 7% increase in the Gross Domestic Product (GDP) of Europe, generating annual savings of €600 billion and creating 170,000 jobs by 2035, a 48% reduction in CO_2 emissions by 2030 and 83% by 2050, and a decrease in raw material consumption of 32% by 2030 and 53% by 2050 [11]. In Europe, urban policymakers have recognized the urgency of transitioning to circular city models through strategic initiatives such as the European Green Deal and the Circular Economy Action Plan [12]. In parallel, the Ellen MacArthur Foundation has played a pivotal role in shaping this landscape influencing urban policy through research, advocacy, and capacity building since 2010. Notably, its 2019 report Cities and the Circular Economy for Food [13] highlighted the central role of cities in the transition to a CE.

Although interest in urban circularity has grown significantly, the literature remains fragmented, often focusing on isolated sectors, emphasizing technical or policy aspects over social and cultural dimensions, and showing a geographical bias toward European cities [14,15]. This fragmentation limits a comprehensive understanding of how circular strategies are implemented across different urban contexts and sectors, highlighting the need for a cross-sectoral and comparative perspective.

Based on these considerations, this study conducts a systematic literature review (SLR) to systematically identify cross-sectoral urban circular strategies and the systemic barriers influencing their implementation across different socio-economic contexts, guided by three research questions (RQ):

RQ1. What circular strategies have been implemented or are being developed at the urban level to enhance circularity in cities?

RQ2. What governance mechanisms and initiatives are identified as key enablers of the urban transition to circular economy models?

RQ3. What main barriers to the implementation of urban circular economy strategies emerge across different contexts and sectors?

The objective is to identify effective strategies supporting the transition toward sustainable and circular urban models, improving citizens' living conditions while safeguarding global ecosystems.

To address the identified research gap and provide a structured and comprehensive analysis of the existing literature, this study is structured around a mixed-methods literature review that combines two complementary approaches: a bibliometric analysis that provides an overview of the scientific landscape, highlighting the temporal concentration of studies, key thematic clusters, leading journals, and geographic distribution, and a systematic review, conducted in accordance with PRISMA guidelines, aimed at identifying and categorizing urban CE strategies.

Unlike studies that focus on individual sectors or regions, this research adopts a cross-sectoral and comparative perspective, enabling a more comprehensive understanding of circular initiatives across diverse urban contexts.

By integrating these methods, this study ensures the rigorous and transparent selection and evaluation of sources, uncovering broader patterns, common barriers, and key enablers that shape the transition toward circular cities.

2. Materials and Methods

The SLR was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines [16]. The review protocol was not registered in any public database, and a formal protocol document was not prepared prior to the review. To ensure transparency and reproducibility of the review process, the full checklist and the abstract checklist according to the PRISMA 2020 guidelines are provided as Supplementary Materials.

However, the methodological procedures, eligibility criteria, and search strategy were defined a priori and are fully described in this section to ensure transparency and reproducibility.

The SLR process was carried out in the following key stages:

1. Source Selection

The primary database used for this study was Scopus (https://www.scopus.com/). Scopus is widely recognized as one of the main sources for citation data and bibliometric analyses, offering broad interdisciplinary coverage that enables comparisons across different research fields [17]. Moreover, comparative studies have shown that Scopus indexes a larger number of journals and provides wider coverage for citation analysis than other major databases, such as Web of Science [18]. Although newer databases may include a higher volume of raw documents, evidence suggests that Scopus ensures more complete and reliable metadata (particularly regarding affiliation data), making it especially suitable for systematic reviews and bibliometric-oriented literature retrieval [19]. In addition, comparative evaluations among PubMed, Web of Science, Google Scholar, and Scopus highlight that Scopus covers a broader range of journals and offers greater utility for both information retrieval and citation analysis, with approximately 20% higher citation coverage than Web of Science [18]. Taken together, these considerations indicate that the selection of Scopus was deliberate and aligned with the interdisciplinary scope, data reliability requirements, and methodological rigor expected in systematic literature reviews, while acknowledging the potential disciplinary and linguistic biases inherent in any bibliographic database. Furthermore, the adoption of Scopus as the single database, rather than combining multiple databases, was intended to optimize the literature analysis process, minimize the risk of duplicate records, and ensure a consistent screening procedure based on the use of standardized and homogeneous metadata.

2. Keyword Identification

The identification of search keywords was guided by a structured and concept-driven approach, directly grounded in the research questions and the conceptual scope of this study. In line with systematic and bibliometric-systematic literature review guidelines [16,20], the definition of the search strategy began with an initial familiarization with the research domain to clarify the key constructs under investigation, namely, circular strategies and their application within urban and territorial contexts.

Specifically, the keywords were derived deductively from the core concepts embedded in the research questions (circularity, strategies, and cities), ensuring a conceptual alignment between the review objectives and the search query. This procedure is consistent with methodological recommendations, which emphasize that search terms should reflect the main theoretical constructs and boundaries of this study in order to enhance the relevance and coherence of the retrieved literature [21].

To further improve the comprehensiveness and robustness of the search, the initial set of keywords was expanded through the inclusion of semantic variants, synonyms, plural forms, and alternative spellings associated with the main constructs. This controlled expansion of terminology reduces the risk of omitting relevant studies due to disciplinary differences in language use and terminological heterogeneity across the CE and urban sustainability literature [21].

The final search string was developed by combining core thematic terms related to circular strategies ("Circular Strateg*" and "Circularity") with geographic descriptors ("City," "Cities," "Region," "Town," "Countr*") in order to capture studies explicitly addressing circular approaches at urban, regional, or national contexts. The final search query applied in Scopus was (Circular Strateg*) AND (Circularity) AND (City OR Cities OR Region OR Town OR Countr*).

The use of wildcard operators (e.g., "Strateg*", "Countr*") allowed the inclusion of terminological variations and reduced the risk of excluding relevant studies due to semantic differences in the literature [20]. By restricting the search to articles where these terms appeared in the title, abstract, or keywords (TITLE-ABS-KEY function), the methodology ensured that results were both precise and directly relevant to the focus of the study on circularity at multiple geographic or administrative scales.

3. Inclusion and Exclusion Criteria

To ensure a focused and high-quality selection, the SLR was limited to:

- Publications written in English;
- Only articles and review papers were included;
- Publications such as editorials, comments, notes, and conference proceedings were excluded.

These criteria were defined a priori to ensure methodological consistency, transparency, and the overall quality of the SLR. The restriction to English-language publications was adopted to enable accurate interpretation and consistent qualitative synthesis, while acknowledging the potential exclusion of relevant studies published in other languages.

The focus on scientific articles and literature reviews reflects the intention to prioritize sources that provide validated methodologies, detailed empirical evidence, and higher scientific reliability.

Editorials, comments, notes, and conference proceedings were excluded to maintain comparability and quality standards across the dataset. While conference papers may present emerging innovations in rapidly evolving fields, they often contain preliminary results and shorter formats and are frequently later expanded or revised in journal publications. Limiting the dataset to more consolidated academic outputs improves comparability across studies.

4. Study Selection, Data Extraction and Quality Assessment

The study selection was conducted in multiple stages by two independent authors to reduce human error and potential selection bias. Titles and abstracts were screened against the predefined inclusion and exclusion criteria, and potentially relevant studies were subsequently retrieved for full-text assessment. Full-text articles were then assessed for eligibility based on the predefined criteria. Following the eligibility assessment, the final set of included studies was organized into a structured Excel spreadsheet to ensure systematic data management.

For each included study, a comprehensive set of variables was systematically extracted to support the qualitative synthesis. The extracted information included: authors, title, year of publication, abstract, geographical context, type of study, main study characteristics, methodological approach, participants, interventions, main results, relevant findings, and the degree of alignment with the research topic. Additional notes were also recorded to document methodological issues, limitations, or critical aspects identified during the analysis. This structured dataset enabled a consistent comparison across studies and supported the identification of recurring patterns, thematic clusters, and gaps in the existing literature.

Due to the heterogeneous nature of the included studies (e.g., literature reviews, qualitative research, quantitative analyses, and interdisciplinary works), a formal risk-of-bias assessment was not performed. This review aims to provide a systematic synthesis of circular city strategies rather than to evaluate the effectiveness of specific interventions, making traditional risk-of-bias appraisal tools less applicable.

5. Four-macro-level framework

The extracted data formed the basis for the categorization of studies into four main thematic areas (Figure 1): (1) urban circularity strategies, (2) architecture and circular construction, (3) waste management and recycling, and (4) food sustainability. These domains were identified inductively from the recurring themes emerging across the selected studies and together constitute the macro-level analytical framework adopted for this review.

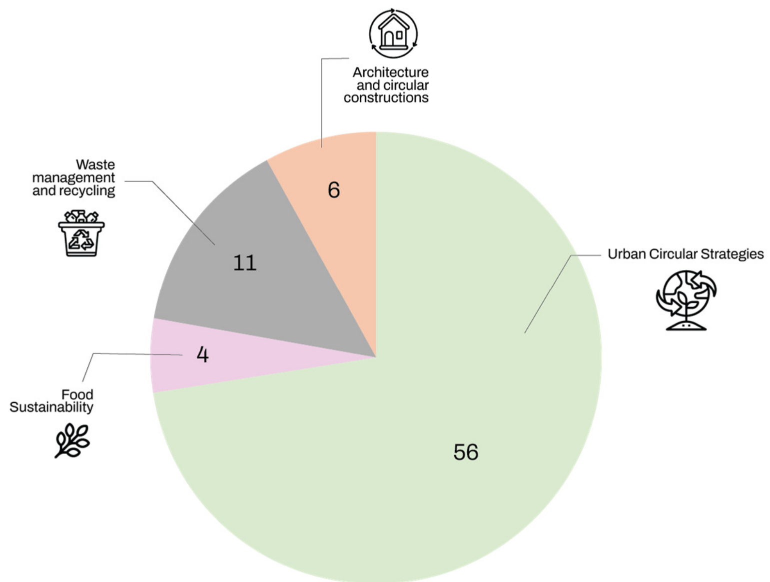

Figure 1. Subdivision of papers into different macro categories.

Adopting this framework allows this review to capture the cross-sectoral and systemic nature of circular city research, enabling a structured and integrated interpretation of how CE strategies, enabling factors, and implementation barriers emerge across different urban contexts.

The number of publications found in Figure 2 through relevant title selection was 363 articles; after applying the PRISMA method, a total of 77 sources were included. A list of these papers is provided in Appendix A.

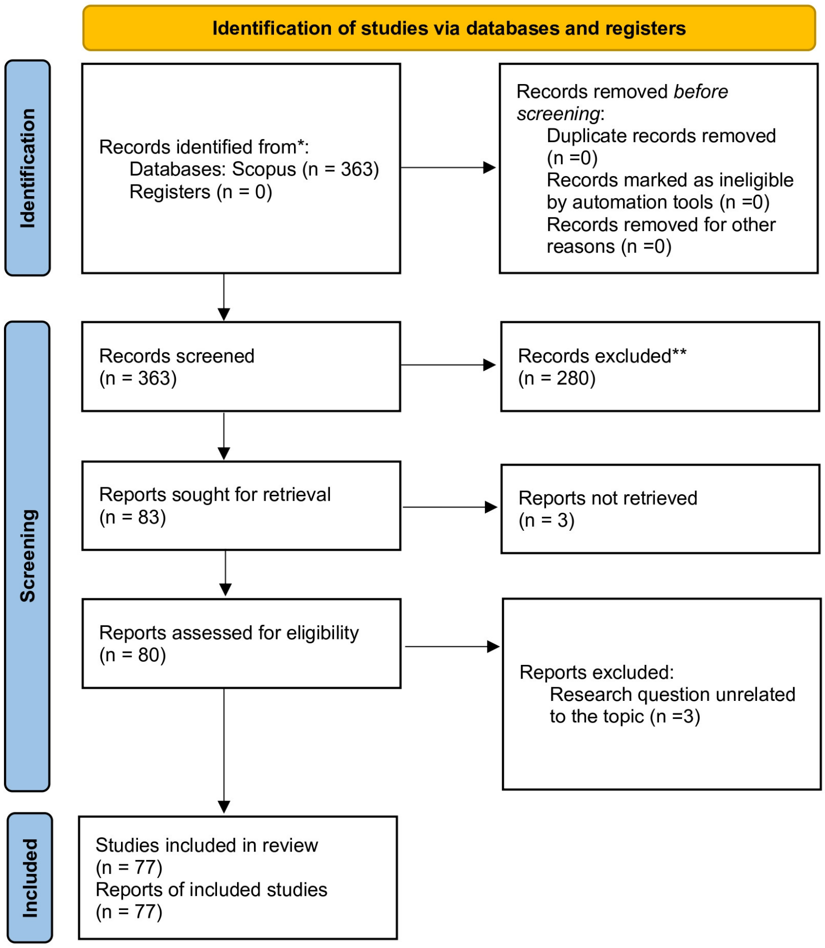

Figure 2. PRISMA 2020 flow diagram of selection process. * Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers). ** If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

This methodological approach enables this study to address the fragmentation highlighted in the existing literature on circular cities in the urban context, which is often characterized by sector-specific analyses, geographical biases, and the limited integration of social, governance, and technological dimensions.

In this context, this research contributes to the literature by providing a cross-sectoral and comparative synthesis of circular strategies, identifying recurring patterns, enabling mechanisms, and systemic barriers across heterogeneous urban contexts. Unlike previous reviews that focus on single domains (e.g., waste, construction, or policy), this study adopts a holistic perspective that captures the interconnections between multiple urban subsystems and circular practices.

The novelty of this study lies in the integration of bibliometric analysis and PRISMA-based systematic review within a unified analytical framework, allowing both a macro-level mapping of research trends and an in-depth qualitative categorization of circular strategies. This approach advances the current knowledge by moving beyond descriptive sectoral analyses toward a systemic understanding of how CE principles are operationalized at the urban scale.

This review is guided by the RQs and the macro-level analytical framework, aiming to interpret how circular strategies, governance mechanisms, and implementation barriers emerge and interact across different socio-economic and geographical contexts.

3. Results

3.1. Bibliometric Analysis

As illustrated in Figure 3, research interest in the field of circular cities has grown significantly since 2018, particularly in relation to articles associated with keywords relevant to the three key research questions. Although a slight decline is observable in 2025, this does not necessarily indicate a reduction in scholarly attention to circular urban transitions.

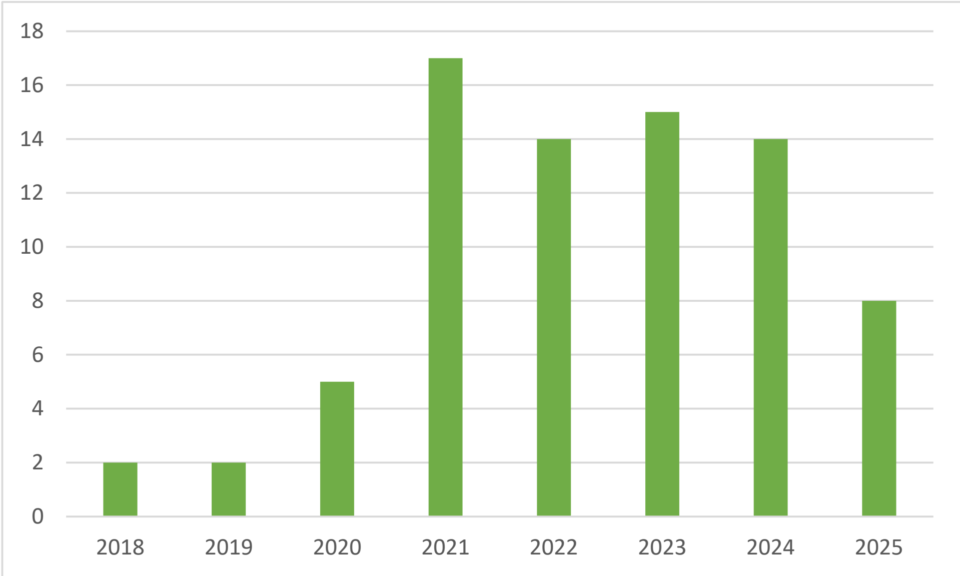

Figure 3. Number of papers per year.

Geographical Distribution and Journal and Research Keywords

Figure 4 illustrates the geographical distribution of the publications. In some cases, studies have been applied in multiple countries or even across different continents, reflecting the international scope of research on circular strategies in cities. Additionally, certain publications involved collaborations between institutions within the same country or across borders. When multiple institutions from the same country contributed to a single study, that country was counted only once.

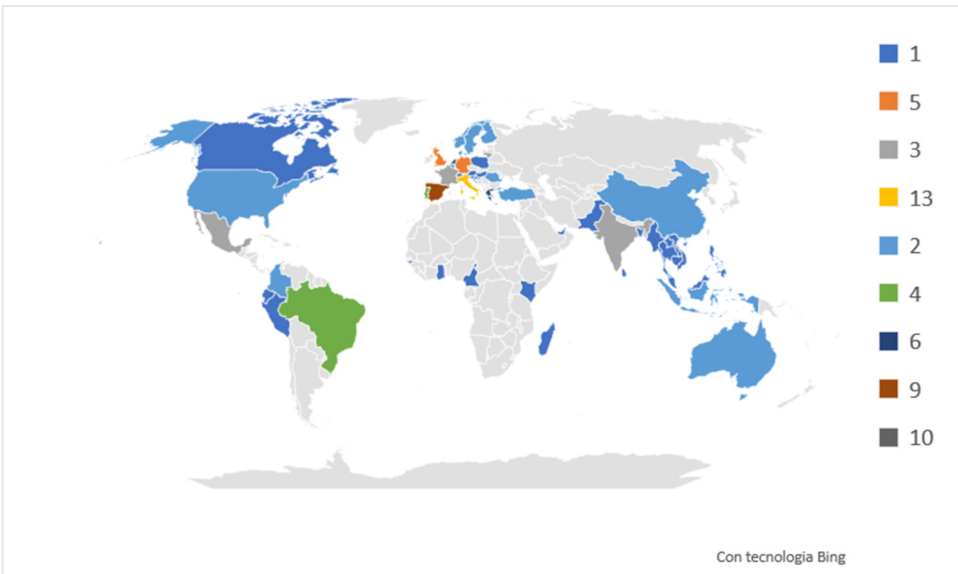

Figure 4. World map of country-based distribution of articles.

The map reveals a high concentration of research activity in Europe, particularly in countries such as Italy, the Netherlands and Germany, with significantly fewer studies focused on non-European regions. Asia stands out for its emphasis on specific key areas, while Africa demonstrates a preference for coastal and insular locations.

European strategies for a CE are characterized by a remarkable diversity of approaches, demonstrating how innovative solutions can be adapted to specific local and sectoral contexts, thus generating significant complementarities, and are supported by robust regulatory and infrastructural frameworks and the availability of significant funding. This spatial pattern can be largely explained by the strong political and financial commitment of Europe to the CE, supported by dedicated EU programs, strategic policy agendas and well-established regulatory and infrastructural frameworks that actively foster research and experimentation at the urban scale.

As illustrated in Figure 5, the journal *Sustainability* stands out as the publication with the largest number of papers on the CE, totaling 14 articles. Following closely behind, both the *Journal of Cleaner Production* and *Circular Economy and Sustainability* each published a total of 8 papers.

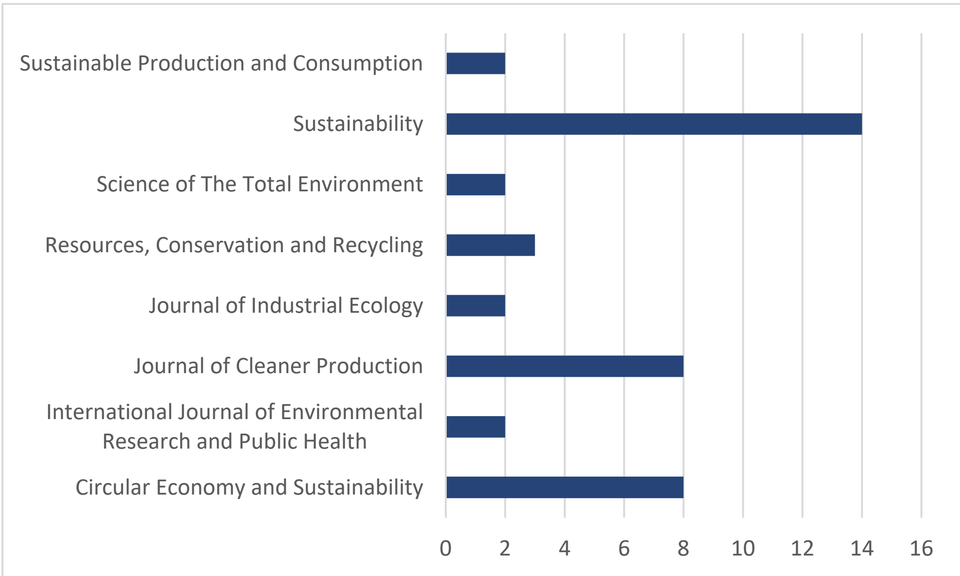

Figure 5. Journals with more than one article on CE.

Keywords were analyzed using the VOSviewer software 1.6.20 to identify conceptual clusters and research trends. The analysis selected terms with a minimum occurrence threshold of 3 and employed binary counting to ensure equal weighting across documents. This methodological choice reduces the risk that highly repetitive terms within a limited number of documents disproportionately influence the network structure, thereby enhancing the robustness of the conceptual mapping.

Frequency analysis showed that generic terms like “circularity” recorded the highest occurrences (49 instances) but lower conceptual relevance, as they appear across diverse contexts. Conversely, more specific terms, including “recycle,” “nature-based solutions,” and “city-level”, demonstrated higher conceptual relevance scores despite fewer occurrences (three instances each), indicating strong and focused thematic connectivity. This divergence between occurrence and relevance suggests that the literature is structured around a set of broad umbrella concepts, accompanied by more specialized and emerging thematic niches that reflect the sector-specific applications of circular strategies. This distinction highlights the importance of analyzing both frequency and thematic coherence:

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frequently cited terms represent broad research interest, while highly relevant terms signal concentrated expertise and established knowledge clusters.

In the graphical representation (Figure 6), the size of each term reflects both its relevance score and its frequency of occurrence, indicating its importance within the keyword network. The colored clusters represent groups of keywords that frequently co-occur in the analyzed literature, thus identifying thematic sub-domains of research on circular cities. Specifically, the clusters highlight interconnected themes related to governance and planning, research and monitoring tools, resource and waste management, and city-level implementation of circular strategies. However, it should be noted that spatial proximity in VOSviewer indicates a lexical association rather than a theoretical or methodological alignment; therefore, the map is interpreted as an exploratory visualization of thematic relationships, to be integrated with the qualitative synthesis rather than considered as a standalone classification tool.

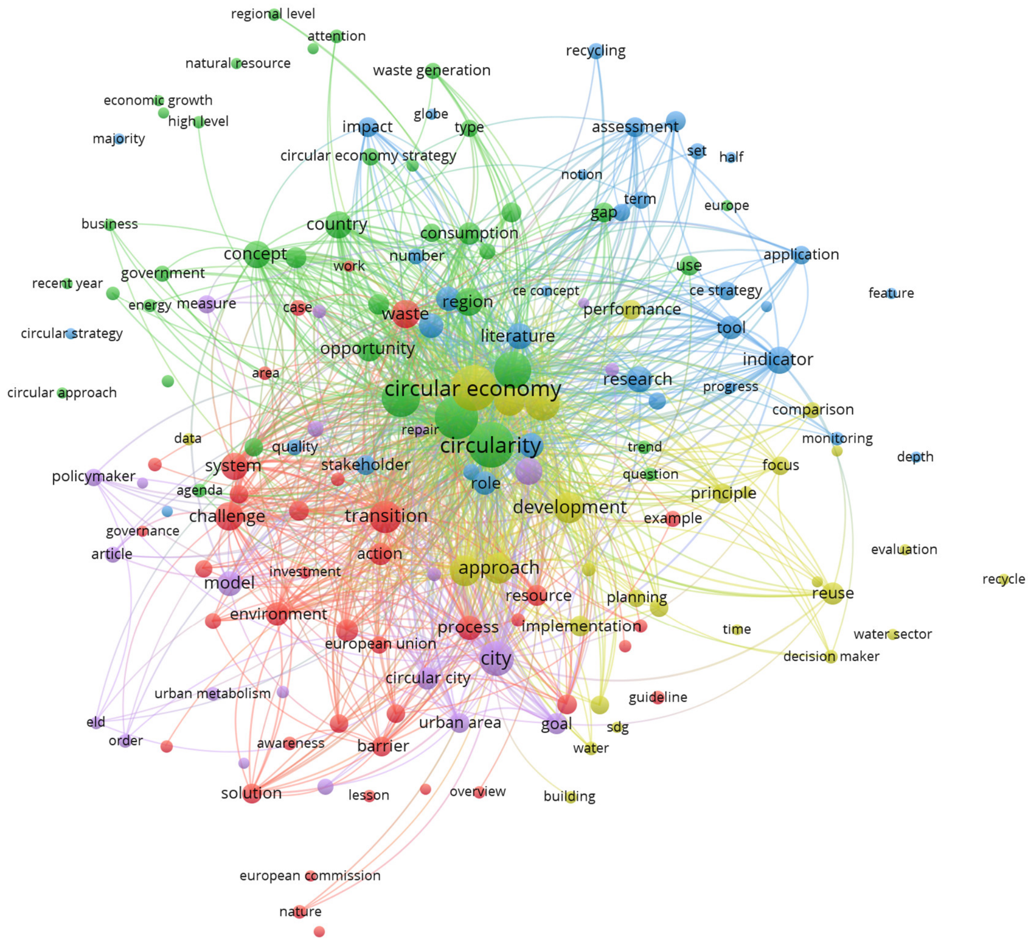

Figure 6. Keywords analysis on VOSviewer.

3.2. Description of the Main Methodologies Applied

The methodologies used in the analyzed articles reveal a variety of approaches aimed at exploring the complexity of topics. A summary of the main methodologies identified across the analyzed articles is presented in Table 1.

Table 1. Summary of methodological approaches in the reviewed literature.

Methodology	% of Articles	Geographical Focus
Literature review	36%	Mostly Europe
Quantitative approach	33%	Europe and global studies
Qualitative approach (interviews, fieldwork)	25%	Europe, South America, Asia, Africa
Interdisciplinary/ Research by Design	6%	Europe

A comparison of these methodological approaches is provided in Table 2, summarizing their main strengths, limitations, ideal applications, and resource demands.

Table 2. Comparison of methodological approaches.

Methodology	Strengths	Limitations	Best Suited for	Resource Requirements
Literature review	Theoretically robust; it maps existing knowledge; useful for global analysis	Less adaptable to local contexts	Theoretical frameworks; identification of gaps in the application of some methodologies in a global context	Low to moderate
Quantitative approach	High precision and replicability; it models flows and impacts	Lots of high-quality data needed	Economic/environmental simulations	High (data access, technical expertise)
Qualitative approach (interviews, fieldwork)	Contextualized insights; it captures stakeholder perceptions	Less generalizable; labor-intensive	Social, institutional, and local studies	Moderate to high (fieldwork, engagement)
Interdisciplinary/Research by Design	It combines theory and practice; flexible; co-creation of solutions; spatially grounded	Demanding in terms of time, facilitation, and local coordination	Applied urban projects; co-design processes	Very high (time, facilitation, infrastructure)

The overall analysis shows that there is no universally "superior" methodology; rather, each approach is suited to specific research objectives and geographic contexts. Theoretical and quantitative methodologies dominate in high-income countries, where access to data and resources is greater, while qualitative and participatory methods are more common in contexts where human interactions and local engagements are essential. This suggests the need to combine diverse approaches to address sustainability challenges with a truly global and multidimensional perspective.

3.3. Overview of the Four Macro-Categories of Circular Strategies

The division into four macro-categories, reflecting the most recurring areas of research and intervention in the literature on circular strategies, allowed for structuring the investigation in a way that aligns with the main challenges and strategies identified in the analyzed studies. Although analytically distinct, these domains are deeply interconnected and often implemented through integrated approaches at the city level. For instance, studies on urban organic waste flows and living labs (e.g., the Pécs Living Lab) [22] show how organic waste management solutions such as composting and anaerobic treatment contribute to closing local material loops and enhancing resource circularity, thereby creating systemic linkages among waste management (macro-category: waste management and recycling), broader urban sustainability (macro-category: urban circularity strategies), and, indirectly, food-related systems (macro-category: food sustainability).

Urban circularity strategies represent the most extensive category, reflecting the central role of cities as coordinators of circular transitions. Architecture and circular construction

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focus on reducing the environmental footprint of the built environment. Waste management and recycling remain a core domain of CE implementation. Finally, food sustainability addresses circularity along the agri-food chain.

3.3.1. Urban Circular Strategies

These strategies address a wide spectrum of actions, including the application of CE principles through the 9R framework (rethinking, redesigning, remanufacturing, repairing, redistributing, reducing, reusing, recycling, and recovering) [23], the development of Urban Living Labs, participatory planning tools, community engagement practices, the use of digital technologies, and the implementation of monitoring indicators [24].

A key strategy focuses on promoting local circular practices through maker spaces and community-driven initiatives. This perspective is further supported by studies on bottom–up urban initiatives that provide "spaces for circularity", such as repair, exchange, borrowing and reuse platforms, which actively extend product life cycles and reduce waste at the local scale [25]. These practices operationalize several 9R principles (particularly repair, reuse, and redistribution) by embedding circular behaviors into everyday urban consumption.

A complementary model is represented by Circular Craft Centers, which act as multi-stakeholder urban hubs integrating repair, reuse, recycling, education and social inclusion, thus advancing material circulation and inclusive urban circularity [26]. Alongside these structured hubs, more informal initiatives such as repair cafés also play a key neighborhood role. For example, Maakbar in Leuven [27] provides tools and knowledge to citizens to restore items like appliances, furniture, and clothing, extending their life cycle. A notable result is the increased repair of household items, supported by local volunteers and municipal incentives.

Further initiatives, including second-hand stores such as Think Twice in Leuven and flea markets in cities like Piraeus and material recovery projects (the Leuven Materialenbank for construction materials), offer accessible platforms for reusing goods, contributing to material circulation and waste minimization [28]. Similarly, Thessaloniki [28], working with a local waste management company, recovered 800 kg of materials, including furniture and scooters, redirecting them to circular production activities. These collaborative efforts highlight how partnerships can improve the effectiveness of urban circular strategies, integrating reuse and recycling into sustainable development frameworks.

Another key strategy is the establishment of Urban Living Labs, as seen in Pécs, Hungary [22], where eco-innovative solutions have been developed, including practices such as promoting home composting through the distribution of 3000 compost bins and recycling 9840 tons of separated organic waste into compost. These initiatives also include the collection of waste oils from restaurants for reuse, highlighting how collaboration within the Living Labs has facilitated the co-creation of effective strategies to accelerate the transition to a CE, enhance sustainable material management, and reduce waste at its source. Similarly, Urban Living Labs focused on socio-ecological innovation, such as nature-based experimental districts and community-led resilience laboratories, demonstrate how participatory experimentation can integrate circularity, regeneration, and ecosystem-based solutions within urban systems, particularly in areas related to water management, biodiversity, and green infrastructure [29].

A further key strategy emphasizes the use of participatory planning tools, particularly Geodesign methodologies, which combine spatial analysis, stakeholder engagement, and impact assessment to co-develop circular solutions [30,31]. For example, the REPAiR project [32] used Geodesign to enhance collaboration through geospatial technologies and dynamic visualization tools, allowing communities to assess and shape spatial and environmental outcomes [31]. Similarly, strategic planning tools such as the Urban Circularity Assessment Framework, implemented in Umeå and Stockholm [33], and an urban planning study conducted on nine African islands [34] highlight how urban governance can integrate social, economic, and environmental dimensions to assess and guide the circular transitions. Other participatory approaches include R-Urban [35] in Colombes, France, which engages citizens in community-led circular activities, such as community gardens, composting, and rainwater harvesting, and the Living Breakwaters [35] initiative in Staten Island, which integrates ecological restoration with community education through workshops. The Reburg project [35] in Flanders explores future urban circularity through a scenario by engaging a wide range of stakeholders. These approaches are particularly effective in the regeneration of marginalized urban areas, highlighting the potential for adaptive reuse and the valorization of peri-urban spaces [36]. This emphasis on territorial specificity allows strategies to be adapted to local needs, taking advantage of the unique characteristics of each context, underscoring circularity through place-based regeneration and the adaptive reuse of degraded lands and fostering stakeholder-driven transitions in marginalized urban contexts [37].

An additional key strategy is the strengthening of community engagement, through awareness campaigns, training programs, and active citizenship initiatives [38]. For example, the Portuguese National Green Roof Association [39] promoted the awareness of Nature-based Solutions (NBSs) through events and institutional collaboration, while education programs through workshops and maker spaces support long-term cultural shifts. However, engagement effectiveness varies significantly: a Colombian study [40] showed that, while 77% of consumers express positive attitude toward CE, only 26% possess adequate knowledge, and only 53% practice circular behaviors, with variations depending on their education and socio-economic status.

Analyzing different engagement typologies reveals that collaborative approaches are most effective in developing tailored solutions, while public education fosters long-term cultural shifts.

Another important strategy concerns the implementation of decentralized governance models, where specific policy guidelines and targeted funding programs have proven to be essential in enabling the systemic adoption of circular practices. Cases from Hungary and Brighton [22,41] demonstrate that participatory frameworks fostered by decentralized structures are more conducive to innovation, while centralized systems often hinder local adaptation. In this regard, local governments are increasingly recognized as key actors in contextualizing and implementing CE strategies, as they can tailor policy instruments, infrastructure investments and governance mechanisms [42] to local socio-economic and environmental challenges, thereby accelerating urban circular transitions [43]. In fact, an analysis of 27 European countries [44] highlighted that nations with comprehensive policy support and significant environmental initiatives achieved outstanding results in CE performance. Moreover, recent planning-oriented studies emphasize that integrating CE principles directly into spatial and strategic urban plans is essential to operationalize circular transitions, as planning instruments can embed circular synergies into land-use organization, infrastructure systems and long-term urban development pathways [45].

A complementary strategy is the integration of sustainable mobility system, such as electric vehicles, as they play a crucial role in reducing environmental externalities [46]. A simulation in a Mediterranean town [47] demonstrated that transitioning to electric mobility as part of a circular development scenario can reduce noise pollution by up to 4 dB(A) compared to baseline conditions. Although noise reduction is not a direct target of CE principles, it represents a valuable co-benefit of circular strategies.

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A further operational strategy is the use of digital tools and platforms. Technologies such as IoT sensors, cloud platforms, and real-time monitoring systems optimize material and waste management [6], reducing inefficiencies and promoting sustainability. Innovations such as smart bins with digital tracking systems [48] have improved recycling rates and reduced landfill dependency. Furthermore, digital platforms support sharing economies and circular business models [49], and the adoption of environmental certifications and tracking tools [50] underscores the growing importance of technology in fostering transparency, accountability, and resilience in urban CE practices.

In addition to digital innovation, another key strategy is the development and refinement of performance indicators. The necessity for measurement tools is central to many strategies, as evidenced by the introduction of standardized indicators for tracking progress toward circularity [51]; although many circularity indicators are applied at the national level, their relevance to urban contexts has often been limited, highlighting a gap in personalized assessment methods [52]. Circularity indicators increasingly encompass not only sectors such as production and consumption, waste management, mobility, secondary raw materials and innovation [11,51,53] but also incorporate social dimensions. For example, a comparative study of Brussels (Belgium) and Recife (Brazil) [54] examining circular jobs revealed 8.51% (Brussels) and 9.96% (Recife) of jobs classified as "circular", respectively, providing valuable urban-level monitoring tools, though comparisons across different economic contexts remain challenging.

Moreover, social indicators, including job creation, training opportunities, and worker safety and protection, can be incorporated into the Social Life Cycle Assessment (S-LCA) methodology [55] to evaluate the social impacts of CE initiatives. S-LCA evaluates the social aspects of products and systems throughout their life cycle, exhibiting potential for measuring the broader social implications of circular strategies. However, its application in CE contexts remains limited and would benefit from significant standardization to enable comprehensive and consistent assessments.

Furthermore, instruments like the Circular Economy Composite Index, employed in the European Union to evaluate advancements toward a circular model [56], and the Emergy Accounting Method, which develops indicators capable of capturing the resources utilized in a process, offer a holistic perspective that integrates environmental, economic, and social dimensions into a unified assessment system [57]. Additional indicators for circular cities and regional material flows enable performance analysis and progress comparisons at various territorial levels [56]. Despite these advances, recent systematic reviews underline the lack of unified and harmonized indicator frameworks and the still limited integration of social dimensions in CE monitoring systems [58], which ultimately constrains the holistic evaluation of CE performance [59].

Although typically associated with the production sector, an additional strategy involves the promotion of industrial circular strategies. In this context, modular and durable product design [60,61] and technologies like waste-to-energy systems and renewable energy solutions contribute to both urban decarbonization and resource optimization. Circular startups, often fostered through city-level initiatives, adopt innovative business models that prioritize reduction, reuse, and recycling [49] and are increasingly supported by public–private partnerships, as demonstrated in Nordic countries, where such collaborations have expedited technological transitions and decarbonization efforts. In particular, Nordic governments play an active role in supporting innovation and technological development through public investment in research and development, green public procurement, and public–private partnerships. In Norway and Sweden, sector-specific climate roadmaps have been developed in collaboration with industry, while in Denmark, the state acts as a facilitator through partnerships and strategies focused on the circular and sharing economy [38]. Key interventions also include the implementation of eco-industrial parks and the promotion of industrial symbiosis practices, as seen in Kwinana [62], where collaboration among firms helps minimize waste within shared urban–industrial ecosystems, particularly in sectors such as textiles and construction, which are characterized by significant environmental impact and complex labor dynamics [63,64]. In these contexts, best practices include promoting material reuse and optimization of urban nutrient and water cycles [65]. Notably, NBS have proven effective in supporting such objectives by managing stormwater, reducing flood risk, and promoting local water reuse. For instance, in Ljubljana, Slovenia, the continued reliance on outdated combined drainage systems contributes to urban pollution and flooding. The integration of green infrastructure, such as permeable pavements, green roofs, and urban wetlands, has been proposed to enhance urban resilience and foster circular water systems [65,66].

Further insights demonstrate that higher Circular Material Usage rates correlate with lower CO_2 emissions, while increasing material footprint correlates in higher environmental impacts [67,68].

Finally, a key emerging strategy is the integration of water-related circular approaches, especially in cities experiencing water stress, pollution, or aging infrastructure. These strategies include, in addition to NBS, circular metrics and reuse systems and demonstrate the potential to align water management with broader circular objectives.

Among the most relevant tools, one major strategy identified in the literature is the application of Water Circularity Indicator (WCI), to quantify and monitor the degree of water reuse and recovery within cities. The WCI ranges from 0 (low circularity, high dependence on virgin water) to 1 (high circularity) and helps benchmark the implementation of 5R strategies (Reduce, Reuse, Recycle, Recover, Restore) [69]. The application of WCI-2.0 assigns weights to each R based on implementation effort [70], offering a more nuanced assessment. Its application in Pimpri-Chinchwad revealed the potential to increase water reuse by 6% and recycling by 10% by 2030, supported by investment in advanced treatment infrastructure [70]. Nonetheless, effective implementation depends on adapting strategies to local conditions and overcoming infrastructural and cultural barriers. National initiatives like the Jal Jeevan Mission further support this transition, but flexibility and local engagement remain critical [70].

At the policy level, a literature review reveals that, although European Circular Economy Action Plans increasingly reference water, the topic is often underrepresented compared to material or waste flows. Notably, only the plans of Mediterranean countries, including Spain, Portugal, Greece, and Italy, explicitly identify water reuse as a priority [71]. However, few national strategies emerge to link water and land management, suggesting a fragmented and incomplete approach to the circularity of urban resources.

The CE necessitates a systemic approach that considers the co-evolution of ecosystems, institutions, technologies, and social practices. This perspective acknowledges the complexity of interactions among various actors and sustainability dimensions [41]. This vision encourages transcending sectoral and territorial boundaries, adopting a collaborative approach that translates complexity into concrete opportunities for a sustainable transition.

In line with this perspective, the SLR identified ten families of urban circular strategies. The results are provided in Table 3.

Table 3. Qualitative synthesis of urban circular strategy families identified in the SLR.

Strategy Family	Evidence Type	Main Impacts	Strengths	Weaknesses	Key Advantages
Promoting local circular practices	Case studies; local initiatives	Product lifespan extension; increased repair and reuse; local material circulation	High citizen engagement; behavioral impact	Limited scalability; volunteer dependence; weak monitoring	Extends product lifespan and reduces local waste generation
Urban Living Labs	Pilot projects; experimental labs	Co-created solutions; improved organic waste valorization; collaborative governance	Innovation-oriented; multi-stakeholder approach	Context-specific; resource-intensive; replication limits	Accelerates experimentation and systemic circular transition
Participatory planning tools	Planning studies; spatial modeling	Stakeholder coordination; integration of circularity in planning; informed decision making	Integrative and strategic; long-term vision	High data/technical requirements; institutional complexity	Embeds circular principles into land-use and strategic urban development pathways
Community engagement and awareness programs	Surveys; education programs; behavioral studies	Increased awareness; behavioral gaps; socio-economic differentiation	Supports cultural change; social acceptance	Knowledge–action gap; uneven participation	Strengthens social foundations of circular transition
Decentralized governance models	Policy and governance analyses	Policy adaptability; enhanced local innovation; improved CE performance	Context-sensitive; flexible governance	Institutional fragmentation; capacity dependence	Enables place-based circular policy implementation
Sustainable mobility integration	Simulation studies; mobility analyses	Reduced environmental externalities; co-benefits (noise/emissions)	measurable co-benefits	High costs	Supports holistic circular urban metabolism
Digital tools and smart technologies	Tech implementation studies	Improved monitoring	Data-driven; scalable; transparency	Technological costs; digital divide; data issues	Enhances efficiency and traceability of material flows
Circularity indicators	Indicator and comparative studies	Improved benchmarking; emerging social metrics; limited standardization	Supports evaluation and policymaking	Lack of harmonized urban indicators	Provides partial and multidimensional assessment of urban circular processes
Industrial circular strategies	Case studies; industrial ecology research	Waste minimization; resource optimization	Large-scale efficiency; systemic resource use	Coordination complexity; sector dependence	Integrates urban–industrial material loops
Water-related circular strategies	Water management and indicator studies	Increased reuse potential; stormwater management; urban resilience	Addresses water scarcity; climate adaptation synergy	Infrastructure and governance barriers	Expands circularity to urban water systems

3.3.2. Architecture and Circular Constructions

This category explores circular strategies in architecture and construction as integral components of broader urban circularity strategies. Studies reveal that the construction sector consumes 36% of global energy and generates 40% of global emissions, underscoring the urgency of circular transformation [72]. Moreover, 45% of all carbon emissions in the United Kingdom stem from existing buildings (e.g., appliances, heating), with 87% of these buildings expected to remain operational by 2050, making their circularization through refurbishment and adaptive reuse essential [73].

To address these challenges, the literature identifies several circular strategies in architecture and construction.

The first key strategy is the use of local and natural materials, which has gained increasing prominence as a means to minimize embodied carbon emissions and reduce dependency on long-distance supply chains. Projects adopting "km 0" approaches not only stimulate the local economy by engaging artisans and local producers but also reduce long-term maintenance costs [72,74]. For example, homes in Palma de Mallorca built with local marès stone and dried seaweed insulation demonstrate how proximity-based sourcing and material recycling can close resource loops and drastically reduce CO_2 emissions [72]. Similarly, the Montessori school in Valencia showcases how the use of durable, natural materials can serve as a replicable model for lowering operational costs through circular design [72].

Another key strategy identified is the adaptive reuse of existing buildings and has emerged as a cornerstone for combining cultural heritage preservation with circular goals. The Edifici Mondo project in the city of Salerno [75] transformed four abandoned historic buildings into cultural and social spaces through a participatory process supported by a multi-criteria evaluation methodology. This intervention mitigated environmental costs associated with new construction (avoiding CO_2 emissions, virgin resource extraction, and construction waste) [74] while fostering social cohesion and enabling educational and cultural activities [75].

A further strategy is NBS, such as green roofs, by promoting resource efficiency, extended material lifespans, and regenerative urban systems [76]. These solutions rely on artificial heating and cooling, thus lowering energy consumption and associated emissions. For example, replacing a conventional roof with a green roof in the UK can reduce environmental impacts from 1.0% to 5.3% and the average lifespan of green roofs may reach up to 40 years, compared to 20 years for conventional roofs [73]. Beyond energy savings, green roofs support water retention, air purification, and local biodiversity, aligning with circular principles that seek to close resource loops and integrate natural systems into the built environment.

Finally, life cycle-oriented design represents another key strategy, focusing on the entire life cycle of building to minimizing environmental impacts. This approach emphasizes the use of reusable and recyclable materials, as well as designs that facilitate disassembly and repurposing. In Italy, where over 6 million unused architectural heritage buildings exist, this approach offers a pathway for revitalization while reducing ecological footprints [77]. In contexts of the global South, recent research highlights the development of techno-typological models based on easily assembled and disassembled systems, locally available resources, and the integration of second-hand building components, aimed at reducing construction costs and environmental impacts across the building life cycle [78]. By prioritizing the longevity and adaptability of materials and structures, this strategy aligns with the principles of circularity.

The included studies on architecture and construction were synthesized through a qualitative comparative approach, identifying four main circular strategy families (Table 4).

Table 4. Synthesis of circular strategies in architecture and circular construction macro-category.

Strategy Family	Evidence Type	Main Impacts	Strengths	Weaknesses	Key Advantages
Local and natural materials	Case studies; architectural projects	Lower embodied emissions; reduced transport impacts; stimulation of local supply chains; cost reductions over life cycle	Local economic benefits; resource loop closure	Context-dependent availability; scalability limits; regulatory and supply constraints	Strengthens local circular material cycles in the built environment
Adaptive reuse of existing buildings	Case studies; participatory regeneration projects	Avoided new construction impacts; reduced resource extraction and waste; enhanced social and cultural functions	Preserves heritage; high resource efficiency	Technical constraints of existing structures; high initial retrofit costs; regulatory barriers	Extends building lifespan and minimizes construction waste and virgin material use
Nature-based solutions	Experimental and applied building research	Extended roof lifespan; improved water retention and biodiversity	Multi-functional benefits (energy, water, ecology); regenerative potential	Higher upfront costs; maintenance requirements; climate and design dependency	Integrates regenerative systems into buildings and enhances resource efficiency and urban resilience
Life cycle-oriented design	Conceptual models; techno-typological studies; life cycle-oriented research	Reduced life cycle environmental impacts; increased material recoverability; adaptability of buildings	Holistic life cycle optimization; design flexibility; long-term environmental benefits	Limited standardization; complex implementation	Enables long-term circularity through durable, adaptable and recoverable building systems

3.3.3. Waste Management and Recycling

Waste management represents one of the most consolidated domains of CE applications in the urban context. It is important to note that several strategies discussed in this section, such as urban wastewater reuse and industrial symbiosis, also emerge in the broader category of urban circular strategies; however, in this domain, they are analyzed from an operational and infrastructure-oriented perspective, specifically focused on waste and resource flow management. The SLR consistently shows that integrated waste management is crucial for reducing environmental impacts, preserving natural resources, and promoting a resilient and circular economic model.

One prominent strategy is the development of integrated waste management models that aim to move beyond traditional disposal-based systems such as landfilling and incineration [79,80]. As global municipal solid waste production is projected to reach 3.4 billion tons by 2050 [81], cities face increasing pressure to adopt more sustainable and systemic solutions. Several studies demonstrated the effectiveness of indicator-based models in optimizing waste flow and improving transparency and efficiency. An example is the m-SWM4Cities model, a multidimensional approach to sustainable urban waste management that is systemic, adaptable to various urban contexts, and utilizes key indicators to evaluate and enhance waste management strategies as shown in its application to Mexico City [81]. Similarly, studies on medium-sized Brazilian cities highlight how sustainability indices reveal the limitations of conventional practices and the need to transition toward more circular models [82].

A further important strategy concerns the extension of circularity principles to the urban wastewater sector through reuse and resource recovery approaches. While water-related circular strategies are also addressed within urban circular strategies at the governance and planning level, here, they are specifically examined in relation to wastewater treatment systems, reuse infrastructures, and resource recovery processes within the waste management domain, especially in Latin America, where approaches vary according to institutional capacity and socio-ecological conditions [83]. In Mexico, the emphasis is on large-scale wastewater reuse for agricultural purposes, particularly in peri-urban regions. One of the largest treatment plants in the world, i.e., the Atotonilco treatment plant, reuses 15 m^3 of wastewater daily, mostly without further treatment, particularly in agricultural regions adjacent to urban centers. It integrates energy recovery, sewage sludge production, and irrigation in the Mezquital Valley. In Chile, there is a marked focus on urban areas, with the transformation of wastewater treatment plants into biofactories in Santiago, aiming to achieve zero waste, energy self-sufficiency, and carbon neutrality. These efforts are supported by a long-term national roadmap ("National Roadmap to the Circular Economy for a Chile Without Garbage 2020–2040") that aligns regulatory, cultural, and territorial pillars to foster CE transitions. Finally, Bolivia demonstrates a bottom–up, community-centered approach: in municipalities like Cliza and El Alto, decentralized wastewater treatment systems facilitate the reuse of treated effluent for irrigation, while promoting local ownership and ecological sanitation through the separation and reuse of graywater, urine, and composted feces [83].

Alongside this, the establishment of industrial symbiosis networks emerges as a crucial strategy for reducing the demand for primary resources. Although industrial symbiosis has already been discussed within urban circular strategies as a systemic and governance-related approach, in the waste management context, it is interpreted more specifically as a mechanism for waste valorization and the reintegration of by-products into production cycles, for example, Smart Symbiosis Networks [84], proposing collaboration between industrial and urban sectors to reduce environmental impacts and economic costs. Moreover, it relies on creating synergies among industries, where by-products of one production process become raw materials for another, thereby reducing the need for new resources and decreasing the amount of waste generated. In the Brazilian context, circular industrial symbiosis strategies are promoted through the integration of water infrastructure, wastewater management, and cooperation between productive sectors, with a particular focus on the valorization of by-products and the optimization of resource flows between urban and industrial stakeholders [83]. Among these strategies, two emblematic cases illustrate how Brazil is applying these principles. The first concerns SABESP, the state-owned water utility of São Paulo, which has launched a program to optimize wastewater treatment plants aimed at (1) increasing the capacity of existing plants, (2) improving the quality of effluents to facilitate their industrial and agricultural reuse, and (3) recovering resources such as water, energy, and biosolids, reintegrating them into production cycles [83]. The second example is in the state of Espírito Santo, where the government has implemented an integrated river basin management project based on NBS and a Payments for Ecosystem Services

(PES) system. In this scheme, landowners provide upstream financial compensation for adopting sustainable agricultural practices and implementing reforestation interventions, actions that improve water quality and reduce sedimentation in river courses. The project generated economic benefits estimated at between USD 13 and USD 18 million, including a direct return for the local water company CESAN, which saved BRL 15.5 million in filtration operating costs [83].

Another strategy involves the adoption of circularity assessment and monitoring tools to support evidence-based waste management such as the Trade-Corrected Circularity Index and the Trade-Corrected Circularity Gap Index [85], which are indicators that consider the trade of waste between regions, accounting for how much a region recycles, including imported or exported waste. Similarly, Waste Circularity Index evaluates three waste types, i.e., electronics, end-of-life vehicles, and municipal solid waste, using a mix of nine indicators to help governments compare and improve waste management policies, and reveals a stark disparity across EU countries: while the average circularity stands at only 10%, nations like Denmark surpass 50% thanks to sophisticated recycling infrastructures [86]. However, adopting these tools requires significant investment in technology and training, which may be beyond the reach of economically disadvantaged regions [85].

An additional strategy adopts a more sector-specific perspective, focusing on waste reduction and material reuse, where circular principles support the optimization of post-consumer material flows and the minimization of waste generation [87]. This strategy is closely connected to the life cycle-oriented design and adaptive reuse approaches discussed in the Section 3.3.2; while the life cycle-oriented design strategy addresses circularity at the design and construction stage, this perspective emphasizes the recovery and reintegration of post-consumer materials at the end-of-life stage within urban waste systems.

Finally, the use of digital technologies and citizen participation mechanisms emerges as a key operational circular strategy. While digital tools and participatory approaches are also discussed in the Section 3.3.1, here, they are specifically framed as instruments for real-time waste flow monitoring, recycling optimization, and behavior-oriented waste reduction. For example, the adoption of advanced tools such as "Unified Waste Metrics" [88] has been shown to optimize waste management by providing a more detailed understanding of economic and environmental impacts, enabling the continuous monitoring of waste flows, the identification of critical inefficiencies, and more informed long-term planning. In parallel, gamification-based applications, such as "WasteApp", can enhance citizen engagement and environmental awareness, fostering improved recycling behavior and a deeper understanding of CE practices [88].

Six operational circular strategy families were identified, focusing specifically on waste and resource flow management (Table 5).

3.3.4. Food Sustainability

In the context of the circular cities, food plays a pivotal role in maximizing resource efficiency. Although this section focuses on food sustainability as a distinct analytical domain, many of the circular strategies identified (e.g., waste reduction, resource recovery, digital monitoring, and collaborative governance) are inherently cross-cutting and recur across other macro-categories. They are discussed here from a food-system perspective, in order to highlight how similar circular principles are operationalized differently depending on the resource flow considered.

Table 5. Synthesis of circular strategies in waste management and recycling.

Strategy Family	Evidence Type	Main Impacts	Strengths	Weaknesses	Key Advantages
Integrated waste management models	Case studies; architectural projects	Waste flow optimization; shift from disposal to circular systems	Systemic and adaptable; decision support	Data and governance complexity	Enables systemic optimization of urban waste and resource flows
Wastewater reuse and resource recovery	Infrastructure case studies; regional analyses	Water, energy and biosolid recovery; reuse in agriculture/industry	High resource recovery; multi-resource valorization	Infrastructure costs; regulatory barriers	Closes water and nutrient loops in urban metabolism
Industrial symbiosis	Industrial ecology studies; regional programs	By-product exchange; reduced primary resource demand	Cross-sector synergies; high resource efficiency	Coordination and governance challenges	Reinforces circular material loops across urban–industrial systems
Waste circularity assessment and monitoring tools	Indicator and comparative studies	Waste flow benchmarking; inefficiency identification; partial circularity assessment	Supports evidence-informed planning	Lack of harmonized metrics; partial scope	Supports structured evaluation of waste circularity (standardization gaps)
Waste reduction and post-consumer material reuse	Material flow and life cycle studies	Post-consumer material recovery; waste minimization	Direct impact on waste reduction	Market and logistical constraints	Enhances end-of-life material reintegration into urban cycles
Digital technologies and citizen participation	Smart waste management studies; behavioral research	Real-time monitoring; improved recycling behavior; efficiency gains	Data-driven optimization; behavioral engagement	Digital divide; adoption and cost barriers	Improves operational efficiency and behavioral alignment in waste systems

One of the main food strategies is the reduction in waste along the entire supply chain, a cross-cutting CE approach that is also central to waste management and urban circular governance, but is considered here specifically in relation to agri-food flows. However, its effective implementation is often constrained by cultural, economic, and institutional barriers that hinder coordination, adoption of innovative practices, and systemic change. In some specific sectors, innovative solutions based on digital platforms are emerging, but their adoption is still limited [89]. In Brazil, for example, only 37.5% of retail companies apply structured practices to reduce food losses, reflecting persistent cultural and organizational constraints [90]. When effectively implemented, digital technologies enable surplus food to be redirected from disposal to consumption, simultaneously addressing waste reduction and food insecurity. Similarly, in public markets in Mexico City, vendors adopt informal food waste reduction strategies, such as price discounts, transformation into prepared products, and redistribution to customers and local communities, showing that grassroot, community-based practices already contribute to circular food systems [91].

The tourism sector, particularly hotels and restaurants, also represents a critical area for sustainable food management, highlighting the need for circular strategies focused on food waste prevention in high-consumption sectors. In Italy, a study [92] found that food waste represents one of the main waste categories with hotels and restaurants generating 160–200 kg CO_2/m^2 and 0.8–1.2 kg of waste per guest per day, 44% of which is organic. Although this is a high-impact sector, the adoption of circular strategies remains limited due to economic and organizational barriers, highlighting the need to extend circular strategies to highly visible, resource-intensive sectors.

In addition to food waste prevention, another key strategy is resource recovery from food waste streams. While resource recovery is extensively discussed in the waste management domain, in the food context, it specifically concerns the reintegration of nutrients and organic flows into agricultural and urban metabolic cycles. In particular, the recovery of nutrients such as phosphorus, as well as energy flows that would otherwise be lost through landfill disposal, represents a crucial pathway for closing urban food loops. This approach is particularly evident in Belgium. Currently, only about 2% of the phosphorus entering the city is recovered within urban boundaries, and theoretical scenarios show that recovery could increase up to 70% only with strong political intervention and substantial regulatory changes [93]. Here, the challenge is not the creation of digital infrastructures but the integration of waste treatment systems that transform urban flows into agricultural resources.

Food traceability and monitoring through technology also play a vital role in enhancing the efficiency of circular food systems. This represents a digital circular strategy that, while common across other urban circular domains, is applied here specifically to optimize food logistics, enhance transparency along the supply chain, and facilitate surplus redistribution, ultimately reducing systemic inefficiencies.

The case of Milan focuses on the digitization of food flows through pilot projects like "Food Market 4.0," which seeks to optimize the efficiency of municipal markets using technologies such as blockchain and IoT to monitor and manage operations. The focus is on traceability and logistical efficiency, as demonstrated by the recovery of 1.5 million kilograms of food annually by SO.GE.M.I. and the 54 tons/year recovered by RECUP, equivalent to a reduction of 21 tons of CO_2 [83,94]. By ensuring that waste materials are repurposed, these initiatives contribute to both environmental sustainability and the reduction in landfill waste. Furthermore, with better data, stakeholders can make informed decisions to reduce waste, improve logistics, and ultimately ensure that food is used more effectively throughout its life cycle.

Finally, collaborative models and local ecosystem-based approaches represent a further strategy for building a sustainable circular food economy. This type of strategy strongly overlaps with urban circular strategies, as governance networks, stakeholder engagement, and local ecosystems act as enabling mechanisms across multiple circular domains, including food, waste, and urban planning. In Milan, partnerships among municipalities, local businesses, universities, and civil society have transformed municipal markets into circularity hubs through EU-funded initiatives such as the REFLOW project [94]. Digital dashboards (Food Market 4.0 Dashboard), food redistribution platforms (Foody Zero Waste), and networks for transforming secondary raw materials (Milano Prima Seconda) illustrate how local ecosystems can operationalize circular principles in food.

These solutions aim to improve product traceability, digitalize logistics management, and strengthen the connection between markets, local producers, and citizens, turning food markets into urban platforms for the CE. In Brazil, while the institutional and cultural challenges are more significant, similar collaborative efforts in food recovery are emerging, showing that localized solutions, tailored to specific regional needs, can drive meaningful change in food sustainability [90,94].

Comparative evidence from Italy, Brazil, Mexico and Belgium shows that, while technological solutions can adapt to different contexts, the success of CE initiatives heavily depends on institutional support and social awareness. These studies indicate that the CE must be supported by localized strategies that account for the social, economic, and infrastructural specificities of each context.

Five main strategy families were identified, focusing specifically on food flows, resource recovery, digital traceability, and collaborative food ecosystems (Table 6).

Table 6. Synthesis of circular strategies in food sustainability.

Strategy Family	Evidence Type	Main Impacts	Strengths	Weaknesses	Key Advantages
Food waste reduction along the supply chain	Case studies; sectoral studies; market practices	Reduced food losses; surplus redistribution; improved resource efficiency	Direct waste prevention; cross-sector applicability	Cultural, organizational, and institutional barriers	Minimizes food waste and optimizes agri-food resource flows
Circular food management in high-consumption sectors	Sector-specific empirical studies	Identification of high-food waste hotspots; emerging prevention practices	High impact potential; visibility in resource-intensive sectors	Limited adoption; economic and managerial constraints	Targets major urban food waste sources in consumption-intensive sectors
Resource recovery from food waste streams	Urban metabolism studies; resource recovery analyses	Nutrient reintegration; organic flow valorization; loop closure potential	Closes nutrient loops; links food and waste systems	Low current recovery rates; regulatory and infrastructural gaps	Reinforces circular nutrient and organic cycles within urban metabolism
Digital traceability and food flow monitoring	Pilot projects; digital logistics studies	Improved traceability; logistics optimization; surplus recovery	Data-driven decision making; transparency; efficiency gains	Technological costs; limited adoption; data integration challenges	Optimizes food logistics and reduces systemic inefficiencies
Collaborative and local food ecosystem models	Case studies; governance and ecosystem analyses	Strengthened stakeholder networks; food redistribution systems; circular market platforms	Multi-actor collaboration; context-sensitive solutions	Dependence on institutional support; context specificity	Integrates local actors into circular food systems and strengthens urban food resilience

3.4. Common Barriers and Implementation Challenges

In addition to the synthesis of circular strategies and enabling mechanisms, this review identified a set of recurring barriers and broader implementation challenges through a cross-cutting analysis of the selected studies. These are presented as a distinct analytical dimension to improve conceptual clarity. The transition toward a CE across various contexts reveals a complex interplay of challenges spanning geographic, sectoral, and strategic dimensions. While specific challenges depend on the local context, these issues converge into common systemic constraints that hinder circularity and underscore the need for integrated, multi-level strategies.

3.4.1. Infrastructural and Technological Gaps

A lack of infrastructure to support circular strategies is a predominant issue across multiple regions. In low-income contexts, structural poverty severely limits the feasibility of circular strategies, as illustrated by rural areas in Cameroon, where 56.8% of the rural population is living below the poverty line [95]. Similarly, the ASEAN countries display considerable disparities between leaders like Vietnam and other countries such as Laos and Myanmar that show stagnant growth due to inadequate infrastructure and insufficient funding [96]. Island economies, such as Samothraki in Greece, underscore the critical dependence on imports, with solid waste production increasing fivefold over less than a century, further complicating the management of resource cycles in isolated regions [63].

Furthermore, technological and methodological challenges further hinder progress. The lack of integration of digital technologies to optimize urban material flows remains a key issue, compounded by insufficient data quality and cybersecurity concerns [48]. Moreover, the adoption of advanced digital solutions such as IoT-based monitoring systems, blockchain platforms, and smart data infrastructures is often constrained in low-income countries by high implementation and maintenance costs, limited technical capacity, and infrastructural fragilities, as also highlighted by studies on CE practices in developing and African contexts [78]. Additionally, a disconnect between research and practice persists, with cities frequently implementing initiatives lacking a robust scientific foundation. This gap highlights the necessity of interdisciplinary frameworks that integrate scientific knowledge with adaptive strategies tailored to local contexts [36].

In the architecture and construction sector, it emerges that although using local or recycled materials [72] can reduce emissions and promote circularity, a major limitation barrier remains in recovering and reusing construction materials. Addressing these issues requires optimizing the end-of-life management of building components and establishing robust remanufacturing and regeneration cycles. This area requires improved infrastructure and strategies to overcome these hurdles [73].

In the urban water sector, the implementation of circular strategies is often constrained by the limited availability of technologies and distribution networks for water reuse, but even where treatment capacity exists, reuse remains marginal. In the case of Pimpri-Chinchwad, secondary and tertiary treatment capacity reaches 353 MLD (million liters per day), yet only 19 MLD (approximately 5.3%) is reused for industrial purposes, largely due to insufficient infrastructure connecting treatment plants to end [70]. Similar constraints are reported in Latin America, where advanced treatment technologies for pollutant removal and water reuse, such as membrane bioreactors or treatments using microalgae, are limited or remain at experimental stages, reinforcing reliance on conventional water supply solutions and increasing pressure on natural resources [83].

In the waste flows, the lack of technological tools for integrated monitoring makes it difficult to identify strategic priorities, as demonstrated in the cases of Brazilian cities and the region of Catalonia, where the absence of coherent and updated data hinders the effectiveness of waste planning and management [82,97].

In the food sector, infrastructural and technological gaps extend beyond organic waste management to include municipal markets and food distribution systems. The Milan case highlights how the lack of digital infrastructure, connectivity, and technical skills among operators restricts the ability to monitor and manage food flows effectively, limiting the transformation of markets into functional circular hubs [94].

3.4.2. Lack of Standardized Indicators and Evaluation Tools

A lack of standardized measurement tools represents another critical barrier, undermining efforts to monitor and evaluate progress in urban circularity effectively. In Europe, only a limited number of countries have developed comprehensive circularity indicators, limiting the capacity for benchmarking and informed decision making [52]. These limitations contribute to pronounced regional disparities, with countries such as Germany and the Netherlands leading circular transitions, while others, including Romania and Malta, lag significantly behind [44,56]. On a global scale, the decline in the circularity index from 9.1% to 7.2% over the past five years highlights the dominance of linear economic models and a widespread resistance to adopting circular systems [98]. In the adaptive reuse and cultural heritage sectors, specific instruments for implementing a CE are limited and require broader application and adaptation to guide interventions toward long-term sustainability. The existing tools often neglect social and cultural dimensions [74], limiting holistic impact assessments. Based on the indicators and assessment tools explicitly referenced in the reviewed literature, a minimal set of essential indicators for circular cities can be identified. These include (1) the Circular Economy Composite Index, used to assess systemic progress toward circularity [56]; (2) territorial material flow indicators for circular cities and regions, enabling performance comparison across spatial scales [56]; (3) social and employment indicators, including circular jobs as well as broader S-LCA metrics such as job creation, training opportunities, and worker protection [54,55]; and (4) emergy-based indicators derived from the Emergy Accounting Method, capable of capturing resource use within circular processes through an integrated environmental and socio-economic perspective [57]. These indicators are not proposed as a predefined universal framework, but rather as a synthesis of the most explicitly operationalized assessment tools identified in the analyzed studies.

3.4.3. Governance Fragmentation and Regulatory Complexity

Governance structures also present limitations, as observed in Pécs, Hungary, where centralized decision-making processes inhibit community participation and the co-creation of innovative solutions [22]. Similarly, in Ljubljana, Slovenia, despite the city being considered a leader in environmental innovation, the application of NBSs is limited by administrative barriers. In fact, long-term strategic plans often fail to align with short-term decisions, and regulatory frameworks do not provide clear guidelines for integrating circularity into urban planning [66].

Operationally, policies governing material flow often prioritize linear solutions. In regional energy systems, material flows are often directed toward energy recovery rather than optimized recycling, undermining the closure of resource loops [53]. In the water sector, especially in Europe, narratives surrounding CE actions often assign water a secondary role compared to other materials and resources, such as waste and metals, thereby limiting its potential in environmental regeneration and integrated urban cycle management [71]. This marginalization is evident in the absence of specific water-related targets in many national CE plans, except for some Southern European countries, such as Spain, Italy and Portugal, which directly address water scarcity issues.

In architecture, governance fragmentation is evident in the variability of circularity-oriented certification systems, such as LEED and BREEAM, across national contexts [72,77]. In Italy, the regionally adopted ITACA protocol often diverges from international standards, creating inconsistencies and offering limited guidance on key aspects such as adaptive reuse, despite its emphasis on land use and resource efficiency [77].

This gap is also highlighted in the waste sector and underscores the profound disparities among different regions of the world. In Africa and the Asia-Pacific, low material recovery is exacerbated by inadequate infrastructure and fragmented policies, while in Europe, despite significant progress, challenges remain regarding cross-border waste management and optimizing the trade of materials for treatment [85]. Another critical factor of the fragmented governance is that waste management is often entrusted to a patchwork of actors (public, private, and community-based) operating in a disjointed manner, with divergent approaches and sometimes conflicting goals. The absence of a favorable regulatory framework, such as tax incentives or supportive policies, further exacerbates the situation, making circular strategies less competitive compared to traditional disposal practices [90].

In the food sector, governance and regulatory barriers reinforce linear resource management. Evidence from Brussels shows that nutrients derived from organic waste are largely lost through incineration or landfilling, despite the availability of recovery technologies. This outcome reflects regulatory and institutional constraints that hinder the adoption of circular solutions and limit nutrient reintegration into agricultural systems [93].

3.4.4. Economic Constraints and Investment Gaps

Funding limitations represent a major barrier to advance the CE progress, exacerbated by the lack of targeted incentives. Beyond economic constraints, this challenge also has ethical implications, as the benefits of circularity are unevenly distributed, reinforcing regional and global inequalities [85,99]. In many cases, policies fail to strike a balance between economic incentives and coercive measures.

The construction sector exemplifies these challenges. In Italy and Spain, the adoption of circular practices is constrained by high upfront investment costs, limited markets for recycled materials, insufficient professional training, and low public awareness. Moreover, the weak perception of competitive advantages associated with circularity, combined with the absence of adequate financial incentives, further delays the implementation of innovative solutions. At the same time, inadequate or overly fragmented regulations can have a paralyzing effect on local initiatives [92,97].

In Italy, despite more than six million unused buildings, adaptive reuse remains limited due to refurbishment costs, particularly for historic buildings, making circular interventions viable only with dedicated financial support [74,77].

Funding misallocation also affects other sectors. In India, investments primarily support centralized wastewater treatment, while decentralized systems with higher circular potential remain underfunded [70].

Similarly, in Europe, a misalignment between local needs and EU funding priorities often limits support for water reuse and green infrastructure projects [66].

In the food sector, the absence of tax incentives and high costs make circular food systems less competitive, with household food waste levels remaining high in several contexts (e.g., approximately 130 kg per year in Brazil) [90].

3.4.5. Socio-Cultural and Behavioral Resistance

From a socio-operational perspective, low levels of consumer awareness and limited public engagement remain central obstacles. In Colombia, only 26% of consumers have an adequate understanding of circular practices, indicating the urgent need for targeted educational initiatives [40]. Furthermore, limited stakeholder involvement in project design, such as in reuse building initiatives, undermines effectiveness and long-term sustainability, a problem exacerbated by inadequate financial incentives [75]. Moreover, public participation is often insufficient or limited to formal consultations without genuine involvement in the co-creation of solutions. In Ljubljana, for instance, citizens are consulted through online surveys or neighborhood meetings, but these processes rarely influence final decisions. The lack of active engagement can reduce the acceptance and effectiveness of proposed circular solutions [66]. Cultural and perceptual barriers further hinder adoption: for instance, recycled water is often considered less safe than virgin water, and waste is rarely perceived as a resource. Such beliefs reinforce linear consumption patterns and reduce the impact of awareness campaigns [70,81,92].

In the food sector, consumers frequently discard foods considered "suboptimal," such as those with irregular shapes or sizes. Furthermore, for example, in Brazil, only 37.5% of companies in the retail sector have specific departments dedicated to food loss prevention, demonstrating limited awareness and attention to the problem [90].

3.4.6. Circularity Gap and Global Inequalities

The disconnect between academic research and urban implementation persists. A central issue is the "circularity gap," defined as the percentage of materials not reintegrated into production processes. Globally, approximately 6 gigatons of unrecovered materials could theoretically be reintegrated into production processes [99]. In Croatia, 50% of urban waste still ends up in landfills despite investments in mechanical–biological treatment plants. Major barriers include poor source separation and incomplete infrastructure, hindering a full circular transition [89]. In Brazil, 40.5% of urban waste is disposed of inadequately. Although 73% of Brazilian cities have adopted some forms of selective collection initiatives (even if in an initial stage), these programs do not yet cover entire cities. However, the inclusion of the informal sector, which handles up to 90% of recyclable materials in certain areas, represents a significant opportunity to improve integrated waste management [82].

These cross-cutting challenges reflect the complex, multi-scalar nature of CE implementation in cities. Infrastructure, policy alignment, financial models, public engagement, and consistent data systems all require simultaneous attention. Without addressing these systemic barriers, the transition to a truly circular, inclusive, and resilient urban model will remain elusive.

4. Discussion

4.1. Contribution of the Four-Macro-Level Framework

A key theoretical contribution of this review lies in the development of the four-macro-level analytical framework, which advances the circular city literature beyond predominantly sectoral and fragmented approaches. The incremental contribution of this framework is to provide a structured integrative model that synthesizes heterogeneous strands of the literature into a coherent macro-level interpretation of circular urban transitions. Rather than treating circular initiatives as isolated sectoral practices, the framework highlights their functional interconnections within urban metabolisms, showing how material flows, food, and built environment co-evolve in circular transition processes. This directly addresses the fragmentation identified in previous reviews and offers a more holistic conceptualization of urban CE implementation.

Furthermore, the framework systematically integrates the main implementation barriers emerging from the literature, thereby guiding future research toward addressing persistent infrastructural, governance, socio-cultural, and economic gaps. In doing so, it demonstrates that circular transitions are not driven by isolated technological or policy interventions, but by the coordinated interaction of governance structures, infrastructural systems, social practices, and sectoral resource loops. In this sense, the four-macro-level framework functions not only as a classification tool but also as a conceptual scaffold that supports a multidimensional understanding of how circular strategies are implemented, scaled, and constrained in real urban contexts.

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4.2. RQ1. What Circular Strategies Have Been Implemented or Are Being Developed at the Urban Level to Enhance Circularity in Cities?

The SLR has highlighted that many cities have initiated ambitious programs, such as market spaces, repair labs, adaptive reuse of buildings, digital waste tracking, and decentralized water treatment, that demonstrate how the CE can be promoted at the local level through material reuse and citizen engagement.

Nevertheless, the implementation varies greatly depending on geographic and institutional contexts. While European cities dominate the published examples, notable practices have also emerged from Latin America and Asia, though often under more challenging structural conditions.

4.3. RQ2. What Governance Mechanisms and Initiatives Are Identified as Key Enablers of the Urban Transition to Circular Economy Models?

The adoption of circular strategies requires targeted initiatives that support the transition from a linear to a circular model. The SLR highlights the importance of integrated and multisectoral approaches in this process.

The transition toward CE models requires supporting governance, inclusive stakeholder engagement, enabling policies and technological innovation. There is a growing call for the co-creation of circular strategies that embed local knowledge, prioritize social equity, and move beyond sector-specific interventions.

Key elements identified include the development of localized circularity indicators, improved alignment of funding mechanisms, and sustained institutional commitment. Economic incentives and access to funding also play a crucial role in driving the transition. While various initiatives have enabled the development and implementation of circular business models in Europe, significant disparities remain on a global scale. In many non-European regions, limited access to funding continues to impede progress toward circular systems.

Technological and digital innovations are increasingly transforming how resources are managed, offering new opportunities for transparency and efficiency. However, these tools require considerable investment and must be supported by clear regulations that address issues such as data security and system interoperability.

Ultimately, advancing circular transitions depends on long-term institutional commitment and the alignment of policies and investments with circular principles. This includes embedding circular strategies into urban planning, prioritizing social equity, and fostering locally adapted solutions that reflect specific socio-economic and cultural contexts. Only through such coordinated and inclusive efforts can the CE deliver on its transformative potential.

4.4. RQ3. What Main Barriers to the Implementation of Urban Circular Economy Strategies Emerge Across Different Contexts and Sectors?

Despite the numerous strategies and initiatives identified, the transition to urban circular economies still faces several challenges. Infrastructural inadequacies, such as the lack of adequate systems for recycling, water reuse, and material recovery, are prevalent even in high-income contexts. Additionally, the absence of standardized tools for measuring circularity progress means that many cities lack reliable data to monitor circular transition progress.

Regional disparities and fragmented governance further complicate the process. While Europe is at the forefront of the transition, significant differences persist between Northern, Southern, and Eastern European countries. The lack of coordination between government levels (local, national, and European) further hinders the adoption of effective strategies. These issues are compounded by regulatory fragmentation, misaligned funding mechanisms, and limited citizen engagement, all of which undermine the uptake of CE principles.

Moreover, cultural resistance to circular practices such as water or food reuse, together with poor awareness of CE principles, reveal the importance of addressing the socio-cultural underpinnings of circularity.

4.5. Comparison with Existing Literature

This review confirms and extends existing findings on the fragmented evolution of urban CE strategies. Previous works have identified the proliferation of sector-specific tools and projects but often lack a comprehensive lens that connects different urban domains [1,5,52]. The four-category framework proposed in this review offers a novel synthesis that allows for both thematic differentiation and systemic analysis.

Furthermore, the inclusion of diverse geographic contexts addresses a key limitation of prior studies. While most existing reviews focus primarily on European cities, this research highlights examples from Brazil, Colombia, India, Cameroon, Laos, and others, offering insights into how CE principles are being adapted under varying institutional and infrastructural constraints. This contributes to the growing recognition that CE must be context-sensitive and adaptable to local social, economic, and environmental realities.

Another key contribution is the emphasis on the interdependence between different dimensions (from social to technical). Where earlier research often emphasizes technology adoption or policy formulation, this review shows that social inclusion, behavioral change, and stakeholder collaboration are equally crucial for successful CE implementation.

At a theoretical level, this review provides a multidimensional lens through which urban circularity can be analyzed and compared. The categorization of literature into four macro-domains is not only descriptive but also offers an analytical framework that can be applied in future studies to benchmark or map circular strategies. It also underlines the importance of transdisciplinary approaches that connect urban studies, policy analysis, environmental engineering, and social sciences.

To move beyond a purely descriptive synthesis and provide a critical comparison of the reviewed studies, Table 7 presents a cross-category comparative analysis highlighting convergences and divergences in the literature across the four macro-categories of circular city strategies.

To improve the readability of the comparative synthesis, a qualitative scoring approach was adopted to visually represent the four macro-categories through a radar chart (Figure 7). The scores (ranging from 1 to 5) do not represent quantitative measurements but indicate the relative intensity of key dimensions (governance role, digital technologies, stakeholder involvement, scale of intervention, and maturity in the literature).

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Table 7. Comparative analysis of the four macro-categories of circular strategies identified in the SLR.

Comparison Criteria	Urban Circular Strategies	Architecture and Circular Construction	Waste Management and Recycling	Food Sustainability
Main focus	Integrated urban governance and systemic coordination of the circular transition	Reduction in the environmental impact of the built environment and circular use of construction materials	Optimization of waste flows	Food waste reduction, resource recovery, traceability, and redistribution along urban food supply chains
Shared circular objective	Closing resource loops at the city scale and fostering cross-sectoral integration	Closing resource loops in the construction sector by extending the life cycle of buildings and materials	Closing material loops by reducing landfill disposal and enhancing resource recovery	Closing material loops by minimizing food waste and recovering nutrients and energy
Key strategies in the literature	Promoting local circular practices, Urban Living Labs, participatory planning, community engagement, decentralized governance models, integration of sustainable mobility system, digital tools, circularity indicators, industrial circular strategies, and water-related strategies	Use of local and natural materials, adaptive reuse of existing building, NBSs, life cycle-oriented design	Integrated waste management models, urban wastewater, industrial symbiosis, circularity assessment tools, material reuse, digital technologies and citizen participation	Reduction in waste, resource recovery from food, digital traceability, collaborative models and local solutions
Main environmental benefits	Emission reduction, resource optimization, and enhanced urban resilience	Lower embodied carbon, energy savings, and reduced use of virgin resources	Waste reduction, material recovery, and improved resource efficiency	Reduced food waste, nutrient recovery, and lower emissions from food loss
Main barriers identified	Fragmented governance, lack of standardized indicators, limited citizen engagement	High retrofit costs, difficulties in material recovery and reuse, lack of financial incentives	Infrastructural gaps, insufficient data availability, and regional disparities	Cultural and behavioral barriers, organizational limits, and weak technological adoption
Interconnections with other categories	Acts as a systemic coordination framework linking all other domains	Strong links with waste management (construction and demolition waste) and urban policies	Closely connected with urban governance and architecture and constructions systems	Strongly linked to waste management and urban governance
Distinctive feature	Systemic and cross-sectoral approach to urban circularity	Technical and life cycle-oriented approach to the built environment	Operational and infrastructure-based approach to material flows	Socio-technical approach focused on behavior, logistics, and food systems

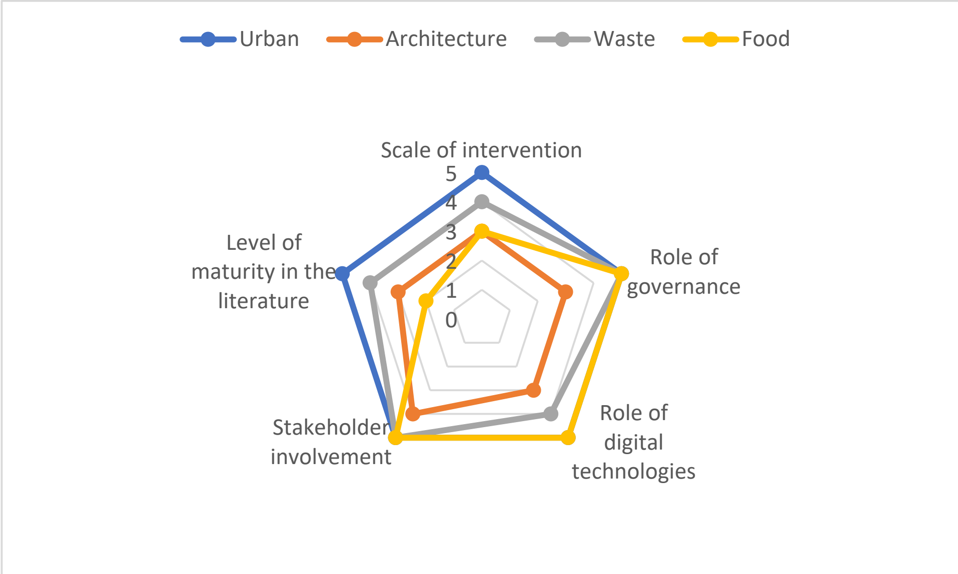

Figure 7. Visual comparative synthesis of the four macro-categories.

4.6. Limitations of the Study

Despite the systematic and transparent methodology adopted, this study presents some limitations that should be acknowledged, some of which were already discussed in previous sections and are systematized here for clarity.

First, as outlined in Section 2 (Materials and Methods—Source Selection), the literature search was conducted primarily using the Scopus database. Although Scopus ensures broad interdisciplinary coverage and reliable metadata, reliance on a single database may have excluded relevant studies indexed elsewhere.

Second, as specified in the Inclusion and Exclusion Criteria Subsection, the restriction to English-language publications may have led to the omission of relevant contributions published in other languages, particularly in regions where CE practices are emerging but less represented in international journals.

Third, as discussed in the Study Selection, Data Extraction and Quality Assessment Subsection, a formal risk-of-bias assessment was not performed due to the heterogeneous nature of the included studies (qualitative research, quantitative analyses, case studies, and literature reviews). While this choice aligns with the exploratory and comparative scope of this review, it limits the possibility of systematically evaluating the internal validity and methodological robustness of each individual study.

Fourth, in the Section Geographical Distribution and Journal and Research Keywords (Bibliometric analysis), the geographical distribution of the analyzed studies shows a strong concentration in European contexts. Although examples from Latin America, Asia, and Africa were included, the overall representation remains uneven, reflecting structural disparities in research production and publication patterns. This imbalance may influence the generalizability of the identified strategies across diverse socio-economic contexts.

Finally, this review exclusively focuses on the peer-reviewed academic literature. Consequently, innovative circular initiatives documented in policy reports, municipal strategies, or gray literature were not included in the dataset and are therefore not represented in the results. Future research could expand the evidence base by incorporating alternative sources to provide a more practice-oriented perspective.

These limitations do not undermine the validity of the findings but rather delineate the scope within which the results should be interpreted and highlight directions for future research.

5. Conclusions

This SLR highlights that the urban transition toward a CE depends largely on institutional, financial, and regulatory factors, as well as the capacity to actively engage citizens, businesses, and other stakeholders, rather than the availability of technological solutions that already exist and can support large-scale circular practices. Their effective adoption therefore requires urban contexts characterized by coherent governance, targeted investments, economic policies that incentivize circular behaviors, and inclusive decision-making processes, in which local experimentation and digital monitoring tools can be integrated with the knowledge and experience of diverse actors. In this framework, the success of circular transition depends not only on the design of effective strategies but also on the ability of cities to learn from concrete results, continuously adapt policies and multidimensional assessment tools, and create conditions conducive to the systemic diffusion of circular practices.

To address current gaps and accelerate change, future research should focus on:

- Investigating how circular practices evolve over time, especially under shifting political or economic conditions;
- Developing robust, transferable indicators to assess circularity at the neighborhood and district scale.
- Integrating bottom–up approaches in decision-making processes to foster more effective engagement of citizens and businesses;
- Expanding analyses to less-studied contexts, particularly in Africa and Asia, to better understand global challenges in urban circularity;
- Exploring the role of emerging digital technologies in supporting the circular transition.

These developments could significantly contribute to addressing existing gaps and accelerating the transition toward truly circular and sustainable urban models. Only through a joint effort between institutions, businesses, and citizens will it be possible to build truly sustainable and resilient cities.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su18062980/s1, PRISMA 2020 abstract checklist; PRISMA 2020 checklist.

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Abbreviations

The following abbreviations are used in this manuscript:

5R	Reduce, Reuse, Recycle, Recover, Restore
9R	Rethinking, Redesigning, Remanufacturing, Repairing, Redistributing, Reducing, Reusing, Recycling, And Recovering
ASEAN	Association of Southeast Asian Nations
CE	Circular Economy
GDP	Gross Domestic Product
IoT	Internet of Things
MLD	Million Liters per Day
NBS	Nature-based Solutions
PES	Payments for Ecosystem Services
S-LCA	Social Life Cycle Assessment
SLR	Systematic Literature Review
WCI	Water Circularity Indicator

Appendix A

Table A1. The list of articles reviewed.

Authors	Year	Geographical Context	Study Design	Key Findings
Aguilar-Hernandez, G.A. [99]	2019	Global	Literature review	A global gap exists between the consumption and the availability of recycled materials.
Alberto López Ruiz, L. [97]	2022	Europe	Quantitative approach	Concrete recycling strategies significantly reduce the environmental impact of urban construction.
Alivojvodic, V. [98]	2024	Europe	Literature review	A new index (CEIR) is developed to simplify circularity measurement in complex systems; the 9R framework provides a robust basis for assessing circular practices, with recycling and reuse being the most frequently applied strategies.
Amenta, L. [36]	2020	Europe	Interdisciplinary/ Research by Design	Wastescape regeneration is identified as a key strategy for building resilient and circular cities; research-by-design proves effective in engaging local stakeholders to address climate change and resource scarcity.
Andriamahefazafy, M. [34]	2022	African islands	Qualitative approach	The CE offers concrete opportunities for sustainable development in island territories.
Atanasova, N. [65]	2021	Europe	Literature review	NBS effectively improve urban resilience and deliver environmental and social co-benefits, though existing infrastructure and regulatory complexity represent significant barriers to broader implementation.
Atkins, Z. [43]	2025	Africa	Literature review	Rapid urbanisation offers a unique opportunity to embed circular principles into new infrastructure by design.

Table A1. *Cont.*

Authors	Year	Geographical Context	Study Design	Key Findings
Banjerdpaiboon, A. [44]	2023	Europe	Quantitative approach	National policies promoting recycling and secondary material use have driven significant improvements in circular performance; underperforming countries can improve by benchmarking against leading nations in sectors such as biowaste recycling and secondary material uptake.
Bianchini, M. [94]	2023	Europe	Interdisciplinary/ Research by Design	Covered markets are identified as potential key nodes for the urban CE, as demonstrated by the annual food recovery via SO.GE.M.I. and RECUP.
Bîrgovan, A.L. [51]	2022	Global	Literature review	Most existing indicators focus predominantly on environmental aspects, neglecting the social and economic dimensions of circularity; a comprehensive framework integrating all dimensions of circular cities, including technology and innovation, is proposed.
Bosone, M. [74]	2021	Europe	Literature review	Systematic approaches to multidimensional indicators remain underdeveloped, with quantitative measures predominating over qualitative ones and persistent gaps in the assessment of environmental impacts.
Brglez, K. [24]	2023	Global	Literature review	Cities are identified as key hubs for implementing the circular economy, given their high concentration of resources and environmental impact; Integrating the governance framework and engaging civil society are crucial to facilitating the circular transition.
Calheiros, C.S.C. [73]	2021	Global	Literature review	Green roofs can extend building envelope lifespan and promote urban resilience through the Water–Energy–Materials–Food–Ecosystems nexus, with cities demonstrating the effectiveness of strong regulatory frameworks.
Chitaka, T.Y. [80]	2023	Africa	Literature review	National strategies prioritize composting and anaerobic digestion for organic waste diversion from landfill; these options are considered commercially established and potentially beneficial for job creation, climate mitigation, food security and energy security. However, stronger circularity would require investment in biorefineries and sector diversification.
Cervantes-Nájera, A.L. [76]	2024	Global	Literature review	Green roofs integrating recycled materials enhance ecosystem services and reduce urban carbon footprints; however, a governance gap persists, as CE strategies operate predominantly at national scale while green roof policies remain city-level.
Colasante, A. [86]	2022	Europe	Quantitative approach	Data harmonisation is identified as a prerequisite for improving the effectiveness of national CE policies.

Table A1. *Cont.*

Authors	Year	Geographical Context	Study Design	Key Findings
Coskun, A. [28]	2022	Europe	Qualitative approach	Cities that have more effectively integrated makerspaces into local policies show greater progress in the transition to urban circularity; Leuven and Venlo exemplify how circular maker ecosystems can thrive through inclusive governance and cross-stakeholder cooperation.
D'Amico, G. [48]	2021	Europe	Qualitative approach	Digital technologies are identified as critical enablers of the CE transition in cities, contributing to improved quality of urban life and reduced environmental impact.
de Lima, F.A. [60]	2024	Global	Quantitative approach	Integrating uncertainty reduction strategies into supply chains is essential to improving circular performance; partnerships with customers, suppliers, and government institutions are crucial to managing recycled material flows and reuse.
Devlin, J. [58]	2023	Oceania	Literature Review	The study finds that South Australia's leadership predates its explicit adoption of circular economy language; its recent policy vision aligns with a planned, modernist circular future, but policy transfer to other Asia-Pacific settings should be approached cautiously and adapted to local realities.
Domenech, T. [87]	2022	Europe	Quantitative approach	A "maximising recycling" scenario reduces greenhouse gas emissions compared to business-as-usual, achieving high recycling and energy recovery rates; Material Flow Analysis indicators effectively identify critical leverage points for improving circularity.
Domingo-Calabuig, D. [72]	2024	Europe	Qualitative approach	Locally sourced architecture produces shorter energy cycles and delivers social and economic co-benefits by engaging local labour and materials, with design strategies adaptable to diverse urban contexts.
Elwakil, R. [27]	2023	Europe	Qualitative approach	Makerspaces promote waste reduction and circular practices, with densely populated and well-connected areas showing greater uptake; reuse and repair activities thrive in accessible urban spaces, whereas material distribution requires more extensive infrastructure.
Fidélis, T. [71]	2021	Europe	Qualitative approach	Inconsistencies are identified in the integration of water and land resources within EU and national CE plans, with geographical factors influencing resource prioritisation and opportunities existing to strengthen synergies between spatial planning and circular economy strategies.
Freitas, M.D.F. [90]	2024	South America	Qualitative approach	Key barriers and enabling strategies for implementing food waste reduction platforms in low- and middle-income countries are identified.

Table A1. *Cont.*

Authors	Year	Geographical Context	Study Design	Key Findings
Furlan, C. [32]	2024	Europe	Interdisciplinary/Research by Design	Geodesign proves effective for engaging diverse stakeholders and co-developing CE strategies, though outcomes are strongly shaped by local data availability and territorial specificities.
Ghazanfari, A. [61]	2023	Global	Literature review	The study highlights that CE strategies such as material recycling and waste-to-energy improve energy efficiency and reduce environmental impact, offering significant potential to reduce fossil fuel dependency and accelerate progress towards net-zero targets.
Gravagnuolo, A. [75]	2024	Europe	Interdisciplinary/Research by Design	A participatory, multi-criteria evaluation using economic, environmental, social, and cultural indicators is conducted; the TOPSIS method is applied to rank different adaptive reuse proposals through an iterative process.
Guibrunet, L. [91]	2025	South America	Qualitative approach	Spatial planning strategies for circular cities include mixed-use development and dedicated space for micro-enterprises; key barriers include high formalisation costs and land-use competition, while mixed-use neighbourhoods and tolerance of informal activities serve as key enablers.
Halog, A. [62]	2021	Oceania	Qualitative approach	Industrial symbiosis has proven successful in areas such as Kwinana through inter-sectoral collaboration; key barriers include the lack of incentives to shift from a linear model and the limited political priority assigned to CE in some jurisdictions.
Henao-Hincapié, L.J. [40]	2024	South America	Quantitative approach	A significant gap in consumer knowledge about the circular economy persists despite government efforts, with education level and socioeconomic status significantly influencing CE adoption and marked differences across cities.
Henry, M. [49]	2020	Europe	Quantitative approach	The study shows that circular startups adopt more radical and innovative business models than large corporations, with platform-based and waste-based models proving particularly effective at generating value from untapped resources.
Herrador, M. [96]	2024	Asia	Literature review	Vietnam is identified as the most advanced ASEAN country in CE implementation, while significant inter-country disparities linked to socioeconomic conditions highlight the need for greater investment and international collaboration across the region.
Jacintos Nieves, A. [81]	2023	South America	Quantitative approach	The m-SWM4Cities model highlights the need for systemic approaches to monitor and optimise urban waste management indicators, identifying both limitations and opportunities for "Zero Waste" strategies.

Table A1. *Cont.*

Authors	Year	Geographical Context	Study Design	Key Findings
Kakwani, N.S. [69]	2022	Asia	Quantitative approach	Implementation of 5R strategies is assessed at the urban scale, with water reduction and reuse identified as priority levers to accelerate urban water circularity.
Kakwani, N.S. [70]	2024	Global	Quantitative approach	The Water Circularity Index (WCI) is proposed as a composite indicator ranging from 0 to 1.0 to assess and monitor urban water flows; higher values reflect efficient water circulation, while lower values indicate excessive virgin water consumption and limited 5R implementation.
Khan, J. [38]	2021	Europe	Literature review	Government policy plays a central role in facilitating the green economy transition through support for innovation and more stringent regulation, with emphasis on enhancing the environmental competitiveness of businesses through targeted green technology promotion.
Lagioia, G. [92]	2024	Europe	Quantitative approach	Food waste management practices in the hospitality sector are analysed, identifying dairy products, pasta, and bread as the main waste categories; higher-star-rated facilities demonstrate greater sustainability awareness.
Lakatos, E.S. [6]	2021	Global	Literature review	The study identifies cities as focal points for circular economy adoption due to their concentration of resources, capital, and data, with technological innovation and stakeholder collaboration highlighted as essential enablers of the urban circular transition.
Lubacha, J. [25]	2025	Europe	Qualitative approach	Community circular practices and consumer self-reported behaviours are mapped against 9R strategies, with physical spaces for exchange, reuse, and repair identified as key enablers of urban circularity.
Luthin, A. [55]	2023	Global	Literature review	The social impacts of CE are complex and involve trade-offs; integration of social indicators into S-LCA frameworks remains limited and requires further development to improve the effectiveness of circular strategies.
Luttenberger, L.R. [89]	2020	Europe	Literature review	The introduction of landfill taxes and the development of biowaste infrastructure are identified as priority policy measures to advance circular waste management.
Marcone, R.D. [52]	2022	Europe	Quantitative approach	Gaps between national bioeconomy strategies and urban-level needs are identified, and improved indicator sets are proposed to enhance the monitoring of bioeconomy performance at the city scale.
Marika, G. [77]	2021	Europe	Literature review	Adaptive reuse reduces resource consumption, waste generation, and land use, but is not yet sufficiently integrated into national protocols.

Table A1. *Cont.*

Authors	Year	Geographical Context	Study Design	Key Findings
Marin, J. [35]	2018	Global	Qualitative approach	Dominant representations of circular cities tend to be technocratic and fail to account for social and political complexity; cities adopting more inclusive and collaborative visions, such as Living Breakwaters, achieve better outcomes in resilience and community participation.
Martínez Moreno, M.M. [56]	2023	Europe	Quantitative approach	A composite index (CECI) is developed as a tool for monitoring circularity progress; policy attention has been concentrated on recycling, with insufficient focus on upstream strategies such as reuse and virgin material reduction.
Matasci, C. [67]	2021	Europe	Quantitative approach	Recycling of metals and electronic waste is identified as crucial for reducing greenhouse gas emissions; increased material reuse in the construction sector and improved recycling of complex waste streams are recommended to advance circularity.
Mbah, M. [95]	2021	Africa	Qualitative approach	The transformation of the Batibo town centre into a CE-based hub for economic, cultural, and social activities is proposed, with expected outcomes including improved rural livelihoods, poverty reduction, and enhanced protection of environmental resources.
Meleddu, M. [50]	2024	Europe	Literature review	Voluntary environmental certifications have positively influenced regional waste management efficiency and the circular transition, with technological innovation playing a key role in improving the efficiency of regional socioeconomic systems.
Moraes, F.T.F. [82]	2023	South America	Quantitative approach	The analysed cities show average waste management performance, with low recycling rates and inappropriate disposal accounting for nearly half of all waste; the USWM-index provides a framework for monitoring improvement, with particular emphasis on integrating the informal sector into waste sorting.
Morgado, M. H. [29]	2025	Europe	Qualitative approach	The urban laboratory Freetown Christiania demonstrates that community-led NBS can replace grey infrastructure and foster circular urban water management; bottom-up governance combined with municipal strategy is identified as a key success factor, while regulatory lock-ins and absent valuation frameworks remain major barriers to scaling.

Table A1. *Cont.*

Authors	Year	Geographical Context	Study Design	Key Findings
Muñoz H, M.E. [54]	2022	Global	Quantitative approach	Significant structural differences between Brussels and Recife shape distinct CE drivers, complicating cross-city comparisons; sectors such as public administration, trade, and transport nonetheless show potential for increased circularity through targeted policies.
Noll, D. [63]	2022	Europe	Quantitative approach	Improving island sustainability requires both increased circularity and reduced overall resource use; recommended measures include reuse of local materials, reduced reliance on imports, and implementation of sustainable energy solutions.
Paiho, S. [46]	2021	Europe	Quantitative approach	Case-study research on a Finnish urban district; three-phase approach including numerical analysis of technological alternatives and related energy/carbon effects, development of service solutions/business models, and review of relevant regulations.
Pakuła, N. [59]	2025	Europe	Literature review	The same Eurostat dataset yields divergent country rankings depending on indicator selection and analytical technique, highlighting critical limitations in CE measurement; harmonisation of indicators, improved data quality, and cautious use of comparative analyses are strongly recommended.
Paoli, F. [11]	2022	Europe	Literature review	A minimum set of indicators applicable across all cities is proposed to monitor and benchmark progress towards urban circularity; improved data collection and standardisation are identified as prerequisites for accurate cross-city assessments.
Papamichael, I. [88]	2022	Global	Interdisciplinary/ Research by Design	Gamified simulations facilitate stakeholder understanding of waste management complexity, with dynamic indicators enabling the testing of policy scenarios and tools such as the Waste Accumulation Index enabling rapid assessment of urban policy impacts.
Papangelou, A. [93]	2020	Europe	Quantitative approach	Theoretical scenarios for food waste and sewage sludge valorisation are assessed; agricultural application of sewage sludge is identified as a strategy with significant potential to improve system-level circularity.
Petit-Boix, A. [42]	2018	Europe	Literature review	Cities mainly promote infrastructure-related strategies and also repair/reuse initiatives, whereas research focuses more on industries and businesses; waste management is a shared focus, but social consumption and urban planning remain insufficiently assessed in environmental terms.

Table A1. *Cont.*

Authors	Year	Geographical Context	Study Design	Key Findings
Pineda-Martos, R. [39]	2021	Europe	Literature review	NBS are identified as essential for advancing urban circularity by combining ecological, social, and economic benefits; collaboration between local stakeholders and international networks is key to broader dissemination of sustainable practices.
Santagata, R. [57]	2020	Europe	Quantitative approach	Circular strategies improve urban sustainability performance; however, most resources remain non-renewable, and a more radical transition towards comprehensive adoption of renewable and locally sourced resources is required.
Sardianou, E. [68]	2024	Europe	Quantitative approach	Green technologies and CE practices have a positive impact on emission reductions, with circular policies integrated into national sustainability plans proving more effective than those applied in isolation to individual sectors.
Soto-Rios, P.C. [83]	2023	South America	Literature review	CE approaches vary significantly across countries, often constrained by limited resources; water is frequently addressed in the context of agricultural and industrial reuse, though a lack of coherence between stated objectives and practical implementation is identified.
Suarez-Visbal, L.J. [64]	2023	Global	Qualitative approach	CE strategies generate employment but frequently reproduce precarious working conditions comparable to the linear model; the repair and reuse sector shows pronounced gender segmentation, with men disproportionately occupying higher-paid roles.
Surekha, K.C. [37]	2025	Global	Literature review	Spatial circularity advances circular cities through regeneration of degraded land, optimisation of urban metabolism, and development of new circular space typologies; urban planning and flexible zoning are identified as key enablers, while social dimensions and monitoring frameworks remain underexplored.
Toboso-Chavero, S. [26]	2025	Europe	Qualitative approach	Circular Craft Centres in the Netherlands demonstrate that bottom-up initiatives integrating reuse, repair, and social inclusion can drive urban circular transitions; a unified framework for holistic evaluation across environmental, social, economic, and spatial dimensions is proposed.
Talamo, C.M.L. [78]	2025	Africa	Qualitative approach	Alternative linear and circular design solutions are developed and evaluated in the Kibera context, exploring the reuse of sheet metal, timber, and tiles as a feasible CE strategy within an enabling policy environment.

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Table A1. *Cont.*

Authors	Year	Geographical Context	Study Design	Key Findings
Taron, A. [79]	2023	Asia and Africa	Literature review	The review identifies three major barriers: waste-related bottlenecks, limited awareness and market knowledge around recovered products, and weak institutional frameworks; conversely, well-structured Public-Private Partnerships can improve technical feasibility, commercial viability and scaling of circular bioeconomy solutions.
Tondelli, S. [45]	2025	Europe	Literature review	CE principles should be integrated across all phases of plan-making, with a holistic, spatially informed approach identified as essential for effective implementation.
Towa, E. [85]	2021	Europe	Quantitative approach	Interregional waste trade significantly alters regional circularity rates, with Wallonia recording the highest rate; trade-adjusted indicators (TCCI and TCCGI) provide a more accurate representation of regional circular performance than conventional methods.
Tsaligopoulos, A. [47]	2022	Europe	Quantitative approach	Circular actions contribute not only to noise reduction but also to broader environmental co-benefits; electric vehicles are found to significantly reduce noise levels, particularly at low speeds.
Tsatsou, A. [66]	2023	Europe	Qualitative approach	Ljubljana demonstrates significant potential for integrating innovative NBS for urban water management and circularity, but requires strengthened institutional structures to scale implementation.
Vanhuyse, F. [33]	2024	Europe	Qualitative approach	Stakeholder participation remains limited at the decision-making level, with city-level CE strategies focused predominantly on waste management, construction, and energy, and insufficient engagement of civil society in CE governance.
Varbanov, P.S. [84]	2021	Europe	Literature review	The study highlights thatindustrial and urban symbiosis networks offer significant potential for reducing emissions and waste; IoT- and blockchain-based systems can optimise stakeholder coordination, but a holistic approach integrating economic, environmental, and social dimensions remains essential.
Varjú, V. [22]	2022	Europe	Quantitative approach	Hungary's highly centralised waste management system constrains local decision-making and hinders the circular transition; Living Labs are identified as effective tools for stakeholder engagement, but decentralised governance structures are required to achieve optimal outcomes.
Virtanen, M. [53]	2019	Europe	Quantitative approach	While energy recovery performs effectively, material circularity remains limited due to insufficient regional recycling capacity, particularly for complex materials such as plastics and textiles.

Table A1. *Cont.*

Authors	Year	Geographical Context	Study Design	Key Findings
Yalçın, N.G. [41]	2021	Europe	Qualitative approach	Brighton and Hove's circular approach is shaped by a strong entrepreneurial culture, environmental activism, and institutional support; key barriers include limited funding, regulatory uncertainty, and inadequate infrastructure to support the circular transition.

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