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RESEARCH ARTICLE

Circular Economy Strategies in European Capitals

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Abstract

As major population hubs, cities contribute substantially to resource consumption and pollution, while also serving as key arenas for innovation and sustainable development. Meanwhile, the European Union has prioritised the circular economy as a strategic pathway for urban transformation, with capital cities intended to have a crucial role in this transition. Drawing on an integrated literature review, this study therefore focuses on the assessment of circular economy strategies in 10 European Union capital cities. It evaluates three core dimensions: methodological clarity, stakeholder engagement, and accountability. Based on these criteria, we propose a typology that classifies strategies into three categories: "Robust", "Moderate", and "Basic". Our findings highlight that, despite growing political commitment to the circular economy at urban level, many strategies suffer from limited stakeholder inclusion, vague implementation plans, and scarce accountability mechanisms. These gaps raise concerns about the disconnect between circular economy visions and urban realities. Overall, this study offers a replicable evaluation tool, while also highlighting the need for integrated, transparent, and participatory planning in the design of effective urban circular economy strategies.

Keywords Circular Economy · Circular Cities · Action Plan · Circular Economy Strategies.

1. Introduction

As the circular economy (CE) becomes central to the global sustainability agenda (Geissdoerfer et al., 2017), its successful implementation will depend on local contexts, with cities playing a particularly key role in this transition (Sánchez Levoso et al. 2020). While national policies are important, successful implementation hinges on effectively addressing local contexts (Hudson et al., 2019; Bourdin and Jacquet, 2025). This requirement to focus the CE on the local urban context stems from several compelling factors. Firstly, the growing relevance of urbanization, given that urban populations are steadily increasing. Moreover, as urbanization has accelerated, cities have become the primary consumers of global energy and materials, and they are now responsible for over 75% of global greenhouse gas emissions (Mahtta et al., 2022). Understanding how cities manage their environmental footprint has thus become critical.

Secondly, cities offer significant potential for CE initiatives. In particular, they act as hubs for economic activity, knowledge, and resource concentration within a defined geographical area (Seto et al., 2012), enabling innovation across economic, environmental, technological, and social spheres (Prendeville et al., 2018), making them a fertile ground for CE implementation (Sánchez Levoso et al., 2020). Moreover, this potential

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has been increasingly acknowledged in the literature, contributing to the emergence and development of the "circular city" concept (Prendeville et al., 2018; Paiho et al, 2020; Pegorin et al., 2024). However, similar to the lack of consensus on the definition of the CE itself (Kirchherr et al. 2023), a universally agreed-upon definition of circular city remains unclear (Prendeville et al., 2018).

Moreover, the debate on circular cities has intensified with the growing recognition that implementing CE activities at the local level increases the likelihood of their success (Hudson et al., 2019). A key challenge lies in bridging the gap between top-down national/regional CE policies and bottom-up local initiatives (i.e. how municipalities can effectively implement CE strategies) (Dagiliene et al., 2021). It has therefore become essential to understand the role that government, corporations, and communities can play in the transition to a CE (Bolger & Doyon, 2019), as well as the dynamics involved in engaging diverse stakeholders throughout the process (Bocken et al., 2018; Buch et al., 2018; Ellen MacArthur Foundation, 2017; Mishra et al., 2019; Kujala et al., 2023).

Despite the growing academic interest in the CE (Kirchherr et al., 2023) there is still a lack of research on how to implement circular strategies in urban contexts (Sánchez Levoso et al., 2020), as well as on how municipalities can implement top-down CE initiatives while also nurturing bottom-up approaches (Dagiliene et al., 2021). Although many studies have focused on specific industries or specific sectors, such as waste management and energy systems (Bocken et al., 2018; Fratini et al., 2019), few have offered a comprehensive analysis of city-wide strategies, including in particular how governance, methodological clarity and participation vary across contexts. It is therefore crucial to explore the political economy of circular cities and urban power structures, when establishing a CE (Prendeville et al., 2018).

This research therefore intends to address these knowledge gaps, by conducting an empirical analysis of CE strategies in European Union (EU) capital cities. The decision to focus on EU capitals is justified, given their strategic importance and distinctive characteristics. In the EU, for example, the European Green Deal, the Circular Economy Action Plan, the Recovery and Resilience Plan, and the New Bauhaus all point to a European agenda focused on green, sustainable and circular development of cities. Moreover, in 2021, there were 72.7 million people living in the EU's 27 capital city metropolitan regions, which represents 16.3 % of the total EU population (Eurostat, 2022).

EU capitals are also often regarded as bustling centres for competitiveness and job opportunities, as well as catalysts for innovation, progress, education, science, social interactions, cultural diversity, and ethnic variety (Akande et al., 2019). In addition, they may exhibit various social, economic, and environmental inequalities, making them focal points for efforts aimed at fostering sustainable and inclusive growth throughout the EU (Eurostat, 2022). Capital cities are therefore subject to more scrutiny and pressure than other locations, and thus play a leading role in promoting sustainable development, while also often being expected to set a reference for other cities across the country to emulate (Dijkink, 2000). By leading the way as policy innovators, developing and implementing policies towards sustainability, capital cities are, as a result, important case studies and interesting subjects of research in general (Czupich et al., 2022). Moreover, given their prominence and capacity for influence, a compelling case can be made for focusing on capital cities as pivotal actors in successfully implementing CE strategies, in particular.

This paper begins with an integrated literature review of both academic and grey literature on CE strategies in urban contexts, which is then used to develop a framework that examines such strategies. The framework draws on three core criteria identified in the literature (methodological clarity, stakeholder engagement, and accountability) and is used to evaluate CE strategies adopted by the 10 EU capital cities that have public CE strategies. The goal is to understand how cities are articulating CE strategies, how these strategies incorporate participatory processes, and also how transparent and actionable the associated plans are.

To address these objectives, the paper first presents the conceptual foundations of the research, followed by the methodological approach and framework. The framework is then applied to 10 EU capital cities, with results and findings discussed. The paper concludes with implications and suggestions for future research.

2. Concept discussion

2.1. The circular economy and the circular city

To date, a universally agreed definition of the CE remains elusive. Nevertheless, over the past decade, various reviews on the topic have identified commonalities among different perspectives and schools of thought (Kirchherr et al., 2023). While concerns about the global allocation of resources, which relate to the CE, were articulated already in the late 1960s by Boulding (1966), recent years have witnessed an explosion in CE definitions (Kirchherr et al., 2023). These include definitions centred on the CE as a system for optimizing material and energy flows, through the promotion of longer-lasting product designs, maintenance, repair, reuse, remanufacturing, reconditioning, and comprehensive recycling (Geissdoerfer et al., 2017) to an economic system that replaces the traditional 'end-of-life' concept with an emphasis on reducing, reusing, recycling, and recovering materials throughout production, distribution, and consumption processes (Kirchherr et al., 2017). The literature also identifies three levels of analysis that help us understand the scale at which the CE is being implemented (Ghisellini et al., 2016): the macro level (involving policies and regulations), the meso level (networks), and the micro level (involving organizations, products, and materials). In particular, when considering CE strategies in urban settings, those are often situated at the meso level, as the focus then revolves around actor interactions (de Jesus et al., 2018; Lakatos et al., 2021).

Although a commonly accepted definition of the CE is lacking, there is, however, an increasing alignment among diverse viewpoints regarding the key principles of CE. In particular, almost 80% of the 221 articles studied by Kirchherr et al. (2023) recognized ‘reuse’ and ‘recycle’ as fundamental principles of the CE. We can, therefore, build on Kirchherr et al. (2017) to define the CE as a systemic approach: aimed at reducing resource use and environmental impact across all stages of production, distribution, and consumption; operating at multiple scales (micro, meso, and macro levels); with the overarching objective of contributing to sustainable development, by integrating environmental protection, economic resilience, and social well-being, while also enabling innovative business models and more responsible consumption patterns (Kirchherr et al., 2017). In this manner, Kirchherr et al. (2023) emphasise sustainable development as the primary aim of the CE, and they also raise concerns about whether the CE concept can reconcile environmental sustainability with economic development, highlighting the need for broader integration of environmental and social dimensions in circular strategies.

Using the above definitions, we frame the CE within a larger context that links resource recovery, reduction, and reuse with urban circular strategies. This context enables a deeper analysis of city-level implementations and their alignment with the 'R hierarchy', thus offering a strong conceptual foundation for our research. In particular, although there is also not yet a commonly agreed definition of a circular city, many authors have found that cities are essential for the implementation of CE strategies (Prendeville et al., 2018), and that by developing a CE, a city can become (1) more resilient, thus less dependent on external factors, importing less and contributing to a better trade balance; (2) healthier, since a healthy environment will also contribute for the well-being of its citizens; (3) efficient, using resources in the best way to use less of them and obtain the same or better results, and; (4) fair, since the service economy can thrive and more people can have access to products that they were previously not able to obtain.

The Ellen MacArthur Foundation (2017) characterizes circular cities as embedding CE principles throughout all urban functions, creating an urban system that is designed to be regenerative, inclusive, and resource-abundant by design. Meanwhile, the European Investment Bank (2018) defines a circular city as one that conserves and reuses resources and products, shares and increases the use and utility of all assets, and minimizes resource consumption and wastage in all forms.

Paiho et al. (2020) offer a comprehensive definition of a circular city, emphasizing the importance of closing, slowing, and narrowing resource loops, whenever possible. Their definition highlights the need to prioritize efficiency improvements, resource sharing, servitization and virtualization, before considering resource recovery or introducing new materials. Ideally, any remaining resource needs should then be met from local and renewable sources.

Meanwhile, according to Prendeville et al. (2018) and Lakatos et al. (2021), a key takeaway regarding circular cities is the necessity for collaboration, as they state that a successful circular city requires a collaborative approach among various stakeholders, including citizens, businesses, policymakers, and knowledge institutions.

Building on this foundation, Pegorin et al. (2024) dive deeper into the characteristics of a circular city. They emphasize efficiency in particular, in terms of identifying resource flows that can be optimized, promoting the recycling, sharing, and substitution of resources for more efficient use, and so regenerating natural resources and environmental services through CE strategies. While financial considerations are important, Pegorin et al. (2024) highlight the need to balance these with positive social and environmental outcomes. Moreover, they also find that, in the most advanced stages of transition, circular cities may even explore dematerialization strategies that virtualize activities and services.

We can, therefore, conclude that a circular city strives to close resource loops (Paiho et al., 2020), by: focusing on a more efficient management of resources, using renewable sources of energy, minimizing resource consumption (Pegorin et al., 2024; Paiho et al., 2020), being regenerative by design, and fostering sustainable consumption and production (Pegorin et al., 2024). Such an approach should also include a wide stakeholder involvement (Prendeville et al., 2018; Lakatos et al., 2021), thus making a city an ecosystem that is resilient environmentally, socially, and economically (Pegorin et al., 2024).

Adapting the concept of the CE to the city perspective is therefore complex (Williams, 2019), requiring a critical reflection on different aspects, from implementation to how to measure and track progress of urban circularity (Prendeville et al., 2018), while also ensuring that municipalities have the right tools and guidelines for a circular transition (Cavaleiro & Fuso-Nerini, 2019). In order to transition to a CE, a city also faces several challenges that need to be overcome (Hobson & Lynch, 2016), including regarding infrastructure, logistics, and the interaction between different agents (Williams, J., 2019; Obersteg et al.; 2019).

Kębłowski et al. (2020) and Iacovidou et al. (2021) note that the introduction of the political economy of circular cities faces challenges relating to the need to embed the circularity principles within the dominant city power structures, including vested interests and path dependencies. A circular city thus needs to be inclusive: consulting and engaging varied stakeholders, from citizens, businesses, and civil society organizations to policymakers and academia (Bolger & Doyon, 2019). Beccarello & Foggia (2022), meanwhile, address the value of new tools, such as circularity mapping frameworks, to help cities benchmark their CE progress across multiple dimensions, including social sharing and resource efficiency.

In conclusion, an analysis of the definitions of a circular city (Prendeville et al., 2018; Lakatos et al., 2021; Paiho et al., 2020; Pegorin et al., 2024) reveals that a successful transition to a CE within cities relies on collaboration among diverse stakeholders, including citizens, businesses, civil society organizations, policymakers and knowledge institutions. Stakeholder engagement therefore becomes essential, to foster this collaboration and achieve the shared vision of a sustainable urban future (Prendeville et al., 2018; Lakatos et al., 2021).

2.2. Stakeholder engagement in CE strategies

The CE provides a pathway towards a more environmentally sustainable and socially just society, with stakeholder engagement playing a critical role in this transformation (Kujala et al., 2023; Bocken et al., 2018; Buch et al., 2018; Ellen MacArthur Foundation, 2017; Mishra et al., 2019; Calisto Friant, 2021).

To understand stakeholder engagement, it is first essential to define what a stakeholder is. According to Soltani et al. (2015), a stakeholder is any individual or group that influences, or is influenced by, decisions made on a particular issue. In the CE context, this includes the “quadruple helix” of government, academia, industry, and civil society with each bringing different motivations, resources, and capacities to the transition process (Zawawi et al., 2023; Wasserbaur et al., 2022). Collaboration across these groups is widely recognized as crucial for successful CE implementation, enabling increased resource value while generating positive social and environmental outcomes (Bocken et al., 2018; Arsova et al., 2021; Geissdoerfer et al., 2017)

becoming increasingly recognized as a strategic enabler of circular business models (Salvioni & Almici, 2020) and as a governance mechanism for urban sustainability transitions (Turcu & Gillie, 2020).

The ladder of participation proposed by Arnstein (1969) provides a useful lens to understand the degrees of stakeholder involvement, from non-participation to full citizen control. Effective engagement at higher levels of participation fosters trust, transparency, and shared ownership, which are essential for the sustainability and legitimacy of public policies (Mohedano Roldán et al., 2019; Van Langen et al., 2021). Incorporating such participatory mechanisms into CE and sustainability policies therefore not only aligns with democratic principles but also enhances policy resilience and inclusivity.

Recent research further indicates that while stakeholder participation is widely acknowledged as essential to CE transitions, the specific actions required to make it effective remain poorly defined (Kujala et al., 2023). Different stakeholder groups have varying levels of awareness, trust, and willingness to cooperate (Giovani Palafox-Alcantar et al., 2020). Understanding these differences and the barriers that hinder their inclusion, is vital for designing more effective CE strategies. For instance, Anantharaman (2021) emphasizes the importance of public involvement and transformational politics in addressing tensions between economic growth and equitable resource distribution.

Empirical studies consistently demonstrate that meaningful stakeholder engagement correlates with more efficient, legitimate, and sustainable CE outcomes (Kujala et al., 2023; Salvioni & Almici, 2020; De Morais et al., 2021). Engagement fosters a sense of ownership and cooperation among actors, which is fundamental to overcoming the governance, behavioural, and institutional challenges associated with implementing CE strategies.

Overall, the literature suggests that the success of developing and implementing CE strategies is intrinsically dependent on the quality of stakeholder engagement. Effective collaboration is not merely instrumental but foundational to achieving the systemic change required for circular urban transitions.

3. Methodological considerations and research design

Acknowledging the subjectivity inherent in research (Creswell, 2013), this study adopts a pragmatic approach. It focuses on how knowledge is built through our actions, contextual situations, and achieved outcomes, prioritizing the most effective methods for the specific research question, grounded in real-world case studies (Ünal et al., 2018) for a nuanced understanding of complex problems (Krohn, 2010).

This study aims to explore how capital cities in the EU have developed CE strategies and action plans since the launch of the European Commission CE Action Plan in 2015, analysing each strategy to understand how these cities are implementing a CE.

The main research questions are therefore:

- RQ1: What are the key trends in how EU capital cities are deploying CE strategies, and what lessons can be learned from their experiences?
- RQ2: How do EU capital cities incorporate stakeholder engagement into their CE strategies?

The research design comprised three phases (Figure 1). First, a review of academic and grey literature on the CE at the city level and related stakeholder engagement was conducted. Second, using the outcome of this literature review, we then developed an analytical framework for assessing city and region-level CE strategies. Third, we identified 10 EU capital cities with publicly available CE strategies, and the framework was then used to analyse these particular cases.

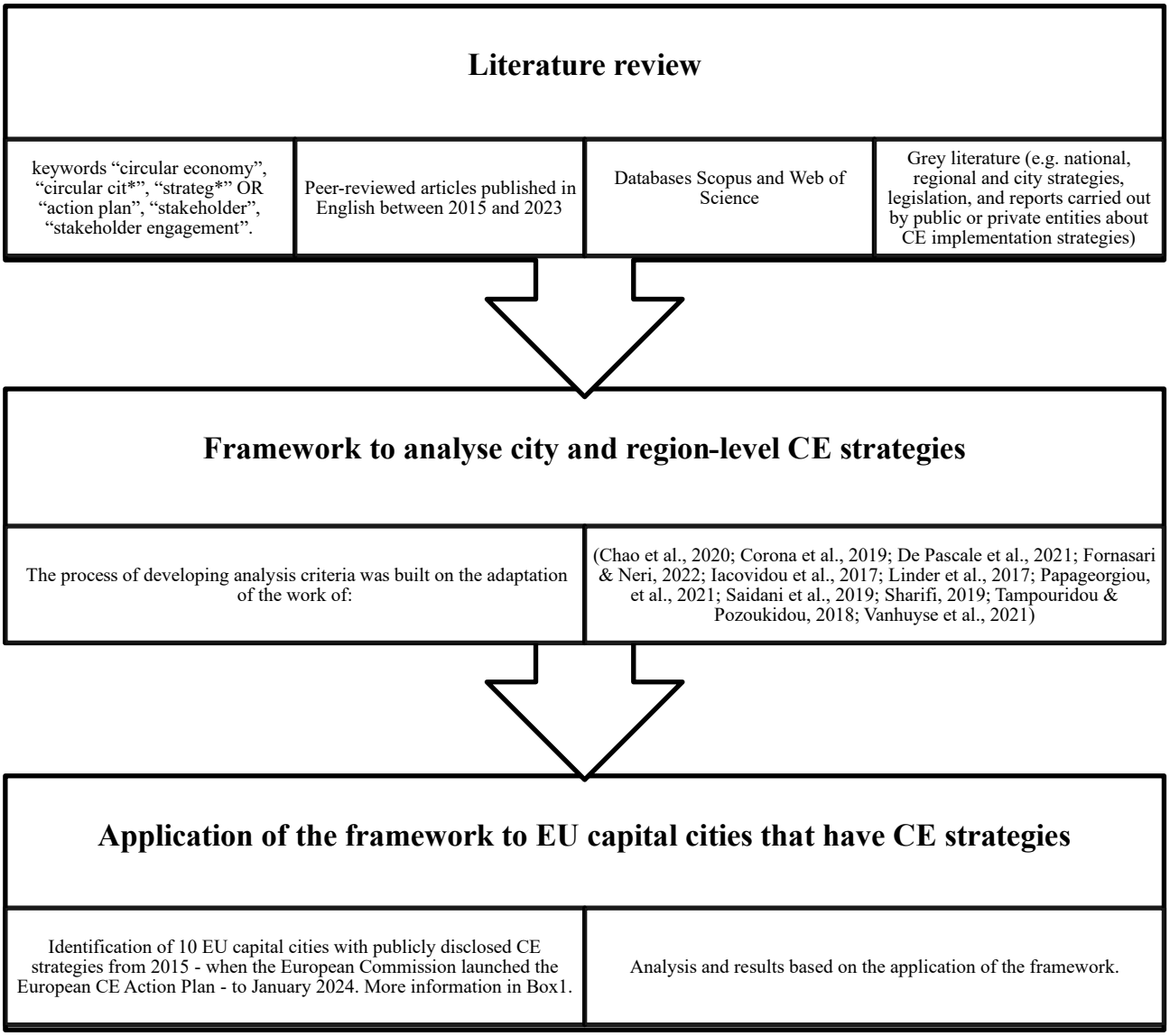

Figure 1. Research Design

3.1. Framework for analysing city and region-level strategies

As a preliminary step in developing the framework, an integrated literature review was conducted. This method allowed for the selection of relevant studies, broadening the sample to include theoretical, empirical, academic, and non-academic sources (Whittemore, 2005). The review focused on clarifying CE implementation strategies at the city level and was conducted using the two main scientific databases Scopus and Web of Science. These two databases combine worldwide coverage of peer-reviewed journals most relevant to this subject (Chappin & Ligtvoet, 2014).

The first step in the review process involved a structured literature search, to identify relevant academic contributions on the implementation of CE strategies in urban and municipal contexts. The methodological approach for defining the sampling frame followed the structured review process proposed by Tranfield et al. (2003), which consists of three key stages: planning, execution, and reporting, ensuring a systematic and

replicable process for selecting literature on CE strategy development, governance, and stakeholder engagement.

For this search, we used the following keywords "circular economy", "circular cit*", "strateg*", "action plan", "stakeholder", "stakeholder engagement". Articles were selected based on their relevance, as indicated by titles and abstracts, and further analysed to extract key themes and insights.

This search focused on articles published between 2015 and 2023, aligning with the timeline of the EU CE Action Plan (2015 onwards), and was restricted by the inclusion criteria of: (1) peer-reviewed journal articles published in the English language; (2) focus on urban CE strategies or implementation at the urban, city, or regional level; (3) explicit discussion of strategy design elements (e.g. stakeholder engagement, R hierarchy and sustainability goals); (4) inclusion of empirical, conceptual, or review papers that inform CE governance, urban sustainability transitions, or CE frameworks. This search thus excluded (a) articles which focused solely on technological innovations or single-sector CE applications without discussing strategy or policy; (b) non-peer-reviewed sources (unless included as grey literature for comparison purposes) and (c) duplicates or publications in other languages.

During the execution phase, the search query returned 52 articles. From these documents the titles, abstracts, and, when necessary, full texts were screened for relevance, based on the predefined inclusion and exclusion criteria, resulting in the exclusion of six documents and a total 46 publications remaining.

Besides scientific literature, grey literature was also included in the research. This included national, regional and city strategies, legislation, and reports carried out by public or private entities concerning CE implementation strategies. These documents were selected based on relevance and were obtained through online searches, conferences, and consulting websites of leading organizations involved in CE research and implementation.

This literature review enriched our understanding of the CE at a city level, providing a clearer perspective on its application, and supporting the definition of a framework to analyse and compare CE strategies. The process of developing the criteria for the framework was built on the review and adaptation of the work of several authors (Chao et al., 2020; Corona et al., 2019; De Pascale et al., 2021; Fornasari & Neri, 2022; Iacovidou et al., 2017; Linder et al., 2017; Papageorgiou, et al., 2021; Saidani et al., 2019; Sharifi, 2019; Tampouridou & Pozoukidou, 2018; Vanhuyse et al., 2021) and the process is documented in Table 1, providing the full list of criteria included in the analytical framework with the corresponding explanations and sources. To strengthen the analytical consistency of the framework, we distinguished between evaluative and contextual criteria.

Table 1. List of criteria used to analyse CE strategies

Type	Criteria	Definition	Source
Contextual	Dates	(a) on what date was it published, and (b) to what dates does the document apply?	Defined by main authors.
	Authorship	Who were the authors of the document (municipality, scholar, private consultants or other organizations)?	Defined by main authors.
	Language	In what language is it disclosed to the public?	Defined by main authors.
	Relevance to sustainable development	To what extent does the strategy include indicators that reflect aspects relevant to the four pillars of sustainable development (environmental, social, economic and governance)? More details in Annex 1.	Adapted from Papageorgiou et al., (2021); Chao et al. (2020); Tampouridou and Pozoukidou (2018).
	Financial instruments	Does the document include any type of financial instruments to support the actions and measures proposed?	Defined by main authors.
	National CE strategy	Did the country already have a national CE strategy before the city or region-level strategy was published?	Defined by main authors.

Table 1 (cont.). List of criteria used to analyse CE strategies

Type	Criteria	Definition	Source
Contextual	Economic Sectors	What economic sectors are addressed in each of the strategies, in terms of the nomenclature of Economic Activities?	Adapted from Vanhuyse et al. (2021)
	Alignment with CE principles	Was the strategy developed based on specific CE principles?	Adapted from Papageorgiou et al., (2021); De Pascale et al., (2021); Saidani et al., (2019)
	R hierarchy	To what extent does each proposed action or measure align with the 10R hierarchy (Reuse, Repair, Reduce, Recycle, Refuse, Rethink, Refurbish, Remanufacture, Repurpose, Recover)? More details in Annex 2.	Adapted from Fornasari & Neri (2022).
Evaluative	Methodology transparency	Is there a transparent description of the methodology for the development of the strategy? Was there a previous city scan or material flow analysis?	Adapted from Papageorgiou, et al. (2021); Corona et al., (2019); Iacovidou et al., (2017); Linder et al., (2017)
	Stakeholder engagement	Were stakeholders engaged through participatory approaches in the development of the strategy?	Adapted from Papageorgiou, et al. (2021); Iacovidou et al., (2017); Sharifi, (2019)
	Accountability	Does the document include some type of accountability for the actions and measures proposed?	Defined by main authors.

The literature consistently highlighted three key factors critical for the implementation of a CE at the city level, specifically (1) clarity of the methodology used to develop the strategy, (2) evidence of stakeholder engagement, and (3) the presence of accountability and monitoring mechanisms (Prendeville et al., 2018; Papageorgiou et al., 2021; Kujala et al., 2023). These dimensions were therefore adopted as core evaluative criteria for classifying city-level CE strategies.

The remaining criteria in the framework, including use of national language, territorial scale (city vs. regional), involvement of external partners, and reference to sustainable development pillars, were analysed as contextual characteristics, providing interpretive insight into the strategies but not used in the typology. This distinction allowed conceptual coherence to be maintained in the evaluation, while preserving the richness and diversity of the case studies.

To allow for a more nuanced assessment of each city's CE strategy, we adopted a three-level codification system for the core evaluation criteria: methodological clarity, stakeholder engagement, and accountability mechanisms. Cities were then awarded zero points when a criterion was not addressed, one point when the criterion was partially or weakly addressed, and two points when the criterion was clearly and substantively addressed, detailed in Table 2. This use of a three-level structure helps to ensure assessment flexibility, enable context-specific interpretation, and enhance transparency and consistency in complex systems (Kofanov et al., 2024). This approach thus provides greater interpretive depth, while ensuring replicability. The typology classification of the strategies was then determined by aggregating the scores for the three criteria and applying a minimum threshold for each.

In addition to the evaluative dimensions used for typology classification, several contextual criteria, including language of publication, territorial scale, involvement of external consultants, and references to sustainability pillars, provide further insight into the strategic orientation and institutional settings of the analysed cities. These indicators, however, do not imply positive or negative value per se but rather highlight contextual realities that shape how strategies were conceived and communicated. For instance, on the one hand, the use of the national language could be seen as promoting local transparency and accessibility, whereas, on the other hand, translation into English language may facilitate international benchmarking. Similarly, the territorial focus of a strategy (city vs. regional) reflects the scale of governance and does not inherently correlate with quality. The presence of external consultants, meanwhile, often compensates for in-house capacity gaps and can bring in valuable expertise, while the reference to, or absence of, specific sustainability

pillars reveals the strategic priorities or conceptual blind spots of each city. Recognizing these indicators as descriptive rather than evaluative supports a more grounded and context-sensitive interpretation of CE strategy development across diverse European governance settings.

Table 2. Scoring of evaluative criteria for CE strategies

Criteria	Question	Scoring explanation
Methodology Clarity	Is the methodology for developing the strategy clearly explained?	0: No description or vague reference to how the strategy was developed. 1: Partially addressed but lacks detail or coherence. 2: Provides a transparent account of methods used (e.g., including circular city scan or material flow analysis).
Stakeholder Engagement	Are stakeholder involvement processes described explicitly?	0: No mention of stakeholder engagement. 1: Generically described without clarity on who and/or how and/or when. 2: Explicit reference to participatory processes of stakeholder involvement, as well as the role of stakeholders in shaping the strategy.
Accountability Measures	Are clear accountability or monitoring mechanisms defined?	0: No mention of follow-up, monitoring, or implementation structures. 1: Vague commitments or unclear references to monitoring tools/actors. 2: Specific performance indicators, timelines, and/or responsible entities are outlined for implementation and follow-up.

Based on the evaluative criteria, each city was assessed against the three core criteria (methodological clarity, stakeholder engagement, and accountability mechanisms) and they were classified into three distinct typologies. "**Robust"** strategies (scores 5 to 6 points), exhibiting strong governance processes, including transparent methodological approaches, clearly described stakeholder involvement, and well-defined implementation and accountability structures. **"Moderate"** strategies (scores 3 to 4 points), reflect partial or uneven attention to these dimensions; while they may demonstrate strength in one or two areas, they fall short of presenting a coherent and comprehensive governance framework. Lastly, **"Basic"** strategies (scores 0 to 2 points), lack transparency in their formulation, provide little or no evidence of participatory processes, and fail to establish mechanisms for implementation oversight or accountability. Annex 3 presents the classification of each city according to this coding scheme.

Overall, the aim of this typology is to provide an analytical and replicable tool for the classification and categorization of CE strategies in EU capital cities. The key benefit of this tool is that it offers a systematic and comparative framework which facilitates the assessment of CE strategy development, identifies emerging trends, and provides valuable insights for policymakers, researchers, and urban planners seeking to enhance the implementation of CE strategies in capital cities.

3.2. Data collection

This analytical framework supported the analysis of publicly disclosed CE strategies of EU capitals that have been published between 2015 (when the European Commission launched the European CE Action Plan) and January 2024. To identify these strategies, we consulted a range of databases and sources (see Box 1).

Box 1. Sources for searching CE strategies in European capital cities

- European Investment Bank (JASPERS list)
- CE Stakeholder platform
- ICLEI
- European Circular Cities Declaration
- OECD database
- Circular Cities and Regions Initiative
- Ellen MacArthur Foundation database
- Circle Economy document database
- Metabolic database
- Google Search in English and in the national language (using Google Translate) with the terms "Circular Economy Strategy OR Action Plan [name of the city]"
- Contacting the responsible people of each city's Circular Economy Club

The selection of the 10 EU capital cities in this study was defined by the research scope as well as the availability of data on CE strategies. In particular, given that many capital cities have not yet developed or fully implemented such strategies, the pool of potential case studies was limited.

In addition, the analysis required strategies that were publicly accessible. The chosen cities therefore represent all available official CE strategies across the EU at the time of the study. Together, however, they do reflect the diversity of geographical, economic, and political contexts across the EU.

This focus on 10 capitals also enabled a detailed case-by-case analysis, while maintaining a manageable scope for qualitative and comparative assessment. Accordingly, we included all official public documents such as strategies, action plans, roadmaps, reports, or bills of law that explicitly reference the CE in their title. The strategies listed in Table 3 were then analysed using the framework described in Section 3.a.

Table 3. List of cities

Title of document	City	Country	Year	Level
Amsterdam Circular 2020-2025 Strategy	Amsterdam	Netherlands	2020	City-level
BRATISLAVA — CITY WITHOUT WASTE - Strategy for managing municipal waste in the city of Bratislava with the aim of transitioning to a circular economy for the years 2021 — 2026	Bratislava	Slovakia	2021	City-level
PROGRAMME RÉGIONAL EN ECONOMIE CIRCULAIRE	Brussels	Belgium	2016	Region-level
Circular Copenhagen - Resource and Waste Management Plan 2024	Copenhagen	Denmark	2019	City-level
The City of Helsinki's Roadmap for Circular and Sharing Economy	Helsinki	Finland	2020	City-level
CIRCULAR POTENTIALS LJUBLJANA 2021-2027, WITH A VIEW OF LJUBLJANA, CIRCULAR CITY 2045	Ljubljana	Slovenia	2022	City-level
PROYECTO DE LEY DE ECONOMÍA CIRCULAR DE LA COMUNIDAD DE MADRID	Madrid	Spain	2022	Region-level
Paris Circular Economy Plan + Paris Circular Economy Roadmap (2 documents)	Paris	France	2017	Region-level
Circular Prague	Prague	Czech Republic	2019	City-level
The Circular Economy in Tallinn, Estonia	Tallinn	Estonia	2023	City-level

The document analysis ensured a thorough comparison of all CE strategies, while the use of the analytical framework provided consistency across various city contexts.

Quality assurance was also ensured by adopting a robust, transparent process. Key documents were cross-referenced across multiple sources, with linguistic consistency achieved through online translators for non-English materials. Additionally, the process was revised by all authors, which ensured accuracy and reliability

in the analysis. The transparency of the methodology, and the inclusion of a replicable framework, further solidified the quality of the analysis.

4. Results

The analysis of the 10 EU capital cities, using the developed framework and informed by the literature review, yielded several key results summarized in Table 4.

Table 4. Main results

Criteria	Results
Dates	Although the European Commission launched the CE Action Plan in 2015, most of these strategies are more recent. 8 out of 10 refer to periods after 2019, as we can see in Figure 4.
Authorship	10 out of 10 (100%) are promoted by an official organization of the city. 3 out of 10 (30%) were developed with the support of private consultancy companies (Prague and Amsterdam both by Circle Economy) or international organisations (support of OECD in Tallinn).
Language	6 out of 10 (60%) strategies are in English. The other four are in their native language (case of Brussels, Ljubljana, Bratislava, and Madrid).
Relevance to sustainable development	All the documents include references to the four sustainable development pillars (Environmental, Social, Economic, and Governance). More details are given in Figure 1. Regarding sustainable development pillars: The most mentioned pillars are "Governance" (33.2% of all actions) and "Economic" (27.3% of actions). "Social" is the least mentioned, comprising 15.1% of actions.
Financial instruments	6 out of 10 (60%) do not mention any financial incentives. 2 out of 10 (20%) mention budgets, but do not detail financing opportunities. Only Madrid mentions sanctions, in case proposals are not fulfilled.
National CE strategy	All the countries of the analysed capital cities have a national CE strategy in place.
Economic sectors	10 out of 10 (100%) mention water and sanitation, which includes water supply, sewerage, waste management and remediation activities. 2 out of 10 (20%) include actions in the transport and storage sector.
Alignment with CE principles	6 out of 10 (60%) clearly explain their alignment with, and their definition of, CE principles.
R hierarchy	Regarding the R hierarchy, we can see the main results in Figure 3: The least mentioned: Refuse, Remanufacture (two times each) The most mentioned: Reuse, Recycle, Rethink (over 50 times each).
Methodology transparency	4 out of 10 (40%) mention clear methodology. 2 out of 10 (20%) do not mention the methodology adopted. 4 out of 10 (40%) give a partial explanation of the methodology. Previous city circular analysis: 5 out of 10 (50%) mention a previous analysis of circularity.
Stakeholder engagement	5 out of 10 (50%) explain a clear stakeholder involvement process. 2 out of 10 (20%) give a partial involvement of stakeholders, by including other relevant documents or plans. 3 out of 10 (30%) do not mention any stakeholder involvement.
Accountability	4 out of 10 (40%) include accountability procedures per action. 1 out of 10 (10%) intends to monitor but does not mention who will do it. 5 out of 10 (50%) mention responsible members but do not detail accountability. Madrid is the only city with a bill of law with sanctions if not executed.

4.1. Uncovering the main trends

Overall, still only a minority of EU capital cities have CE strategies: just 10 out of 27 capitals (i.e. 37%) had a CE strategy at the date of the study, even though all of them had a national action plan in place. According to Hudson et al. (2019) the successful implementation of a national policy is dependent on the local context, reinforcing the importance of local actions and emphasizing the effectiveness of local measures compared with a dispersed national policy (Hudson et al., 2019). However, all the strategies analysed have actions or measures specific to the city or region, with a total of 162 actions identified.

Three cities had support from external consultants (Prague and Amsterdam with Circle Economy and Tallin with OECD) but all of them were promoted by an official institutional member of the city, showing a distinct top-down approach in most of the strategies. All of them included an introductory message from key decision-makers (Mayor or Minister) which shows clear involvement of policy actors in the subject. Nevertheless, we see that only 50% of the cities mention a clear stakeholder involvement in the development of the strategy. Although academic authors, such as Kirchherr et al. (2023), Prendeville et al. (2018), Lakatos et al. (2021), Klein et al. (2020), and Papageorgiou et al. (2021), emphasize the paramount importance of this issue, their advice thus appears to be largely overlooked in practice. This top-down approach is also seen when analysing the reference of the four sustainable development pillars (Environmental, Social, Economic, and Governance), where a clear prevalence can be seen for actions within the governance pillar (33.2% of all the actions), while the social pillar is the one that is least mentioned (15.1%). According to Vanhuyse et al. (2021) the social dimension is commonly under-represented in CE strategies, including issues such as people's way of life (employment opportunities), community cohesion and political systems (Vanhuyse et al., 2021). This aligns with the present results, as the social dimension was found to be the one least addressed: of all the actions analysed in our research, we found that only 15.1% of them are aimed at the social issues (Figure 2).

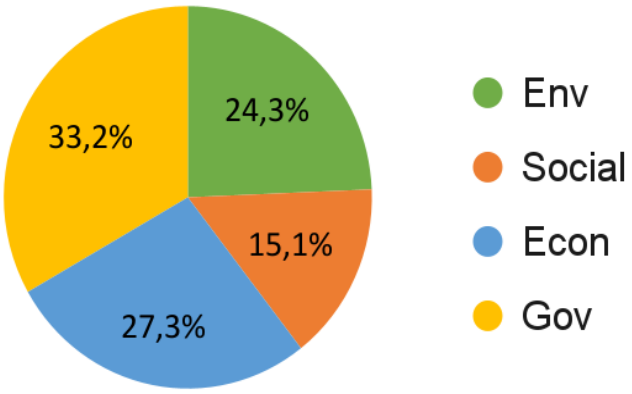

Figure 2. Percentage of actions divided by sustainable development pillar

Even though a clear political involvement can be discerned, including the involvement of key decision-makers such as Mayors or Ministers mentioned earlier, this does not necessarily mean that the CE is being implemented. In particular, there is a clear lack of financing measures outlined in these strategies, along with an absence of accountability mechanisms and performance indicators in the actions proposed (50% of the strategies do not include specific accountability procedures for the actions proposed). Nonetheless, 8 out of 10 strategies (80%) include procurement measures to help promote circularity in the city, showing interest from governments to use the procurement tool as an enabler.

With respect to the R hierarchy, none of the cities addressed all ten Rs in their strategies. "Refuse" and "Remanufacture" were the least considered, while "Reuse," "Recycle," and "Rethink" were the most frequently referenced, each appearing more than 50 times (Figure 3).

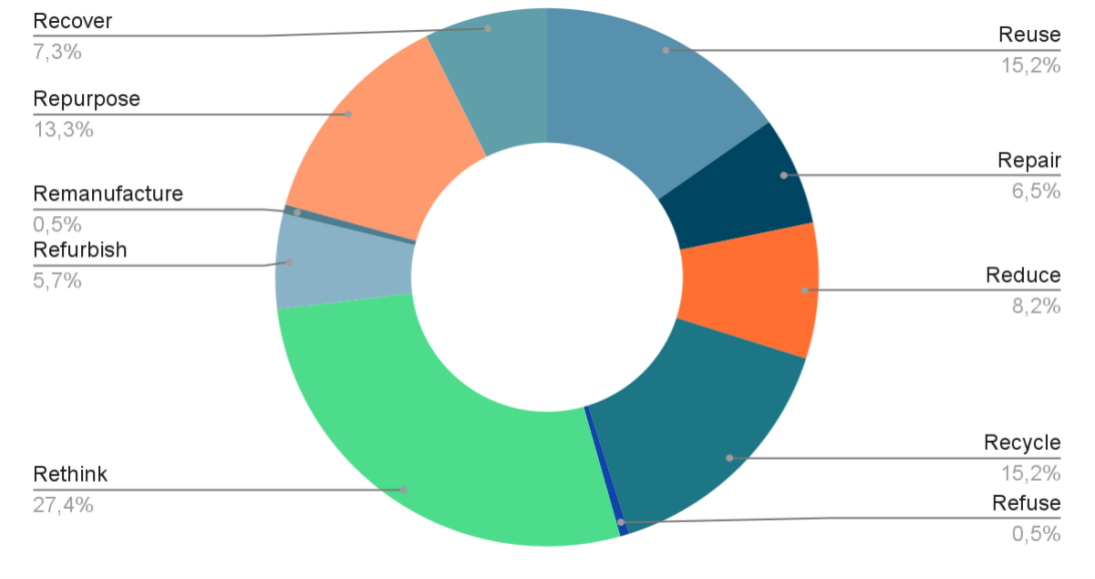

Figure 3. Percentage of actions aligned with the R hierarchy

Only 4 of the 10 strategies (40%) provided a clear description of their methodology. Similarly, 5 out of the 10 (50%) do not mention any previous analysis of the circularity of the city (Material Flow Analysis or Circular City Scan) leaving it unclear as to how the strategic sectors and specific actions were chosen.

Regarding the language of publication, 6 out of the 10 strategies (60%) were written in English, while the remainder were published in the respective national languages (French-Belgium, Slovenian, Slovak, Spanish). This choice may reflect a prioritisation of internal communication and engagement with local stakeholders. Publishing in the national language can enhance transparency and accessibility for the local population, ensuring that the strategy is understandable and relevant to those directly affected by its implementation. While translation into English can facilitate international benchmarking and knowledge exchange, it thus may hamper effective local civic engagement.

Regarding the number of strategies disclosed per year, Figure 4 shows that new strategies have emerged only sporadically, with only one or two being released annually. Despite the increase in academic literature about circular cities (Prendeville et al., 2018) and CE (Kirchherr et al., 2023) there is thus still only a minority of EU capital cities with a CE strategy.

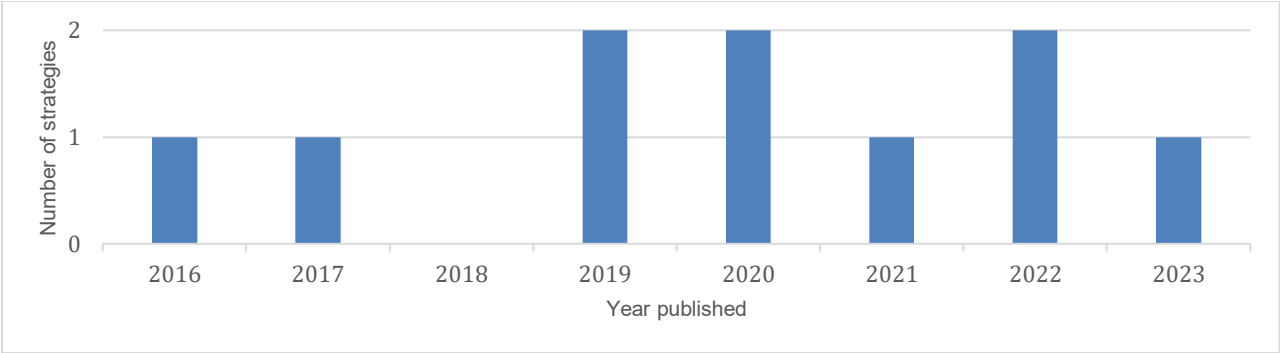

Figure 4. Number of CE strategies of EU capital cities per year

All 10 strategies addressed the water and sanitation sector (water supply, sewerage, waste management, and remediation) and 8 of the 10 (80%) also included actions in construction and the built environment. This

emphasis confirms prior findings that urban CE strategies remain largely focused on waste management (Vanhuyse et al., 2021; Kirchherr et al., 2017; Kębłowski et al., 2020).

4.2. Types of CE strategies

Following the analysis of the CE strategies in the 10 EU capital cities, three distinct types of strategies can be discerned: "Robust" strategies that outline a clear methodology, actively involve stakeholders, and assign clear accountability for the actions proposed. This includes Amsterdam, Helsinki, Prague and Tallinn. "Moderate" strategies that demonstrate partial or inconsistent attention to those dimensions. This includes Brussels, Ljubljana and Paris, where CE strategies contain elements of stakeholder engagement or accountability but lack overall transparency or methodological coherence. Finally, "Basic" strategies are those with minimal or no reference to how the strategy was developed, how stakeholders were involved, or who is responsible for implementation. This includes Bratislava, Copenhagen and Madrid. Table 5 summarizes the key differences among the three types, while Annex 3 presents the detailed coding of evaluative criteria.

Table 5. Comparison of types of CE strategies

Criteria	Analytical framework	Robust (5-6 points)	Moderate (3-4 points)	Basic (0-2 points)
Methodology	**Evaluative criteria**	Clear methodology outlined	Unclear or absent methodology	No description or vague reference to how the strategy was developed
Stakeholder Involvement		Actively involve stakeholders	Partially addressed	No mention of stakeholder engagement
Accountability for Actions		Clear accountability assigned	Vague commitments	Unclear accountability
Language	**Contextual criteria**	Written in English	Varied languages	Varied languages
Focus Level		City-level strategies	City and regional-level strategies	City and regional-level strategies
External Consultants		Prague, Amsterdam, Tallinn strategies were developed with the support of external consultants.	No external support mentioned.	No external support mentioned.
Sustainable Development Pillar (Government)		Cities with over 40% of the actions proposed in the "Government" sustainable development pillar	Cities with less actions in the "Government" sustainable development pillar (less than 29% of actions)	Cities with average actions in the "Government" sustainable development pillar (between 24% and 36%% of actions)
Cities		Prague, Helsinki, Amsterdam, and Tallinn	Brussels, Ljubljana and Paris	Copenhagen, Bratislava, Madrid

Figure 5. illustrates the geographical distribution of the cases by typology: Robust (blue), Moderate (green), and Basic (red). Although our sample size is relatively small, we can note that Robust strategies are generally more represented in northern Europe.

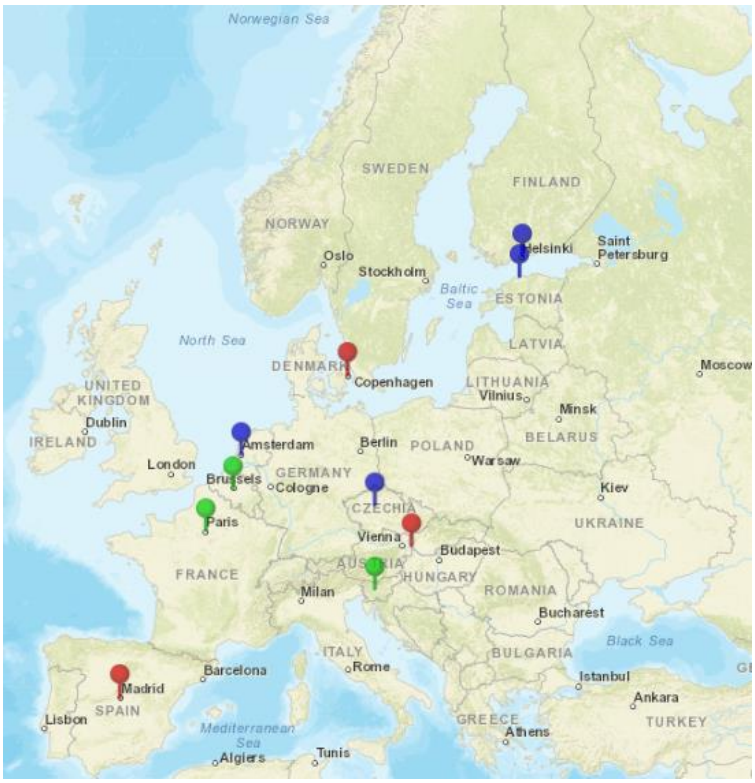

Figure 5. Geographical distribution of the cities analysed in this study

We can identify some broad trends from this analysis. Strategies developed in partnership with external entities (Prague, Amsterdam, Tallinn) tend to be "Robust", suggesting that collaboration between public entities and external consultancies can enhance transparency and accountability. Cities with "Robust" strategies have a significant focus on governmental actions within the Sustainable Development Pillar (over 40% of actions) and are written in English.

5. Discussion

Our analysis of the 10 CE strategies reveals several cross-cutting themes that provide insights into how CE planning is currently interpreted and operationalised in different EU capital cities. A first observation concerns the predominance of top-down governance in the formulation of many strategies. In many of the strategies analysed, the development process showed little evidence of stakeholder co-creation, with only half of the cities explicitly describing participatory processes during strategy drafting. This finding corroborates concerns raised by Prendeville et al. (2018) and Bolger & Doyon (2019) that urban CE initiatives often fall short of translating collaborative principles into practice. As Arnstein's (1969) ladder of participation suggests, the quality of participation should be assessed not by its mere presence, but by the degree of influence stakeholders are afforded in shaping the outcomes. In many of the strategies analysed, this influence is notably limited. Cities that rely on participatory governance systems appear more likely to engage stakeholders systematically, as we can see in both Amsterdam and Helsinki, where multi-level governance and civic participation are well institutionalized (Bosman & Rotmans, 2016). While the Netherlands is known for facilitating bottom-up innovation and participatory governance through regional clusters and cooperative networks (Bosman & Rotmans, 2016), Finland maintains structured governance approaches that incorporate citizen involvement, especially at the local level (Bosman & Rotmans, 2016). This may explain why Amsterdam and Helsinki have developed more robust CE strategies, and this also aligns with prior research indicating that participatory governance systems can enhance the adaptability and contextual relevance of policy interventions, particularly by fostering inclusivity and responsiveness to local needs (Bolger & Doyon, 2019; Fratini et al., 2019).

A second general theme relates to the lack of methodological transparency. In most cases, cities either omitted or provided only vague descriptions of the processes used to identify priority areas, design interventions, or structure their CE roadmaps. This absence of clarity undermines both replicability and accountability, as highlighted by Papageorgiou et al. (2021) and Iacovidou et al. (2017). Although some cities (such as Amsterdam, Prague, and Tallinn) incorporated circularity scans or material flow analyses into their preparatory work, these practices were far from consistent across the sample. What also can be highlighted is the limited inclusion of financial measures across most of the strategies analysed. The absence of detailed financing plans raises questions about the feasibility and long-term sustainability of the proposed actions, suggesting that the implementation of CE strategies may be hindered by resource constraints.

The third theme concerns the persistent disregard of the social dimension of sustainable development within CE strategies. Consistent with the observations of Vanhuyse et al. (2021), our study found that only 15.1% of the 162 analysed actions explicitly addressed social objectives such as equity, inclusion, employment, or citizen wellbeing. This imbalance raises important concerns regarding the emergence of technocratic CE models that may neglect issues of justice and redistribution, as previously discussed by Kirchherr et al. (2023) and Calisto Friant et al. (2021). By overlooking distributional concerns, cities thus risk missing an opportunity to align CE transitions with broader goals concerning justice and public legitimacy. This is a concern emphasized by Berry et al. (2021) in particular, who highlight the lack of attention to justice and inclusion in CE discourse. Addressing this imbalance is therefore essential, if CE policies are to fulfil their promise of delivering inclusive as well as resource-efficient cities.

A fourth theme is the overemphasis on lower-value actions in the R hierarchy. “Recycle” and “Reuse” dominate most strategies, while upstream measures such as “Refuse” and “Reduce” receive comparatively little attention. This narrow interpretation of circularity suggests an incremental rather than transformative approach, which echoes critiques in the literature (Fratini et al., 2019; Kirchherr et al., 2017; Fornasari & Neri, 2022) that many CE policies remain rooted in waste management and thus fail to achieve a systemic rethinking of production and consumption models as CE ecosystems (Aryee et al. 2025).

Finally, a fifth theme highlighted in our analysis concerns the enabling role of transnational partnerships in strengthening CE strategies. Cities that collaborated with specialised external organisations, such as Circle Economy (Amsterdam, Prague) or the OECD (Tallinn), tended to produce more structured, transparent, and participatory documents. These partnerships appear to mitigate capacity constraints, provide access to analytical tools, and facilitate benchmarking against international best practices. This suggests that transnational networks and knowledge partnerships can support cities, by enabling institutional learning, providing technical assistance, and enhancing legitimacy through alignment with broader sustainability goals (Cavaleiro & Fuso-Nerini, 2019; Fratini et al., 2019).

Together, these five themes underscore a central tension: while cities are increasingly adopting the CE discourse, many strategies lack the procedural robustness or transformative ambition required to fulfil the vision of a just and sustainable circular city (Prendeville et al., 2018; Lakatos et al., 2021; Pegorin et al., 2024). Addressing these gaps requires not only technical solutions, but also governance innovation, deeper stakeholder inclusion, and more critical reflection on what circularity means in practice.

Stakeholder engagement emerges here as a pivotal element in the successful deployment of CE strategies in EU capital cities. In particular, the findings of this research demonstrate that cities with more transparent and inclusive stakeholder processes tend to exhibit higher levels of accountability, making them more resilient (Kujala et al., 2023). These findings underline the need for governance structures prioritizing stakeholder engagement as a key mechanism for achieving CE goals. Aligning with previous studies, our research also reinforces the argument that stakeholder collaboration enhances the legitimacy of CE strategies (Kujala et al., 2023; Hudson et al., 2019). Moving forward, cities should thus strive to institutionalize participatory mechanisms, ensuring that stakeholder voices are integrated into CE strategies. Additional research in this area is therefore required.

In general, participatory mechanisms were applied inconsistently across the 10 strategies: while some cities describe clear stakeholder co-creation processes, others either omit this dimension entirely or reference generic stakeholder roles without describing how or when they were engaged. This inconsistency highlights a gap

between declared commitments to participation and actual practice, a concern echoed in literature on urban CE planning (Kujala et al., 2023; Prendeville et al., 2018).

Overall, our analysis thus identified clear trends in how EU capitals are deploying CE strategies (RQ1). Most strategies are shaped by top-down governance and exhibit varying levels of methodological transparency. While some cities, particularly those with established participatory governance systems, such as Prague, Helsinki, Amsterdam, and Tallinn, demonstrate more robust and contextually relevant strategies, many others show limited procedural clarity, weak integration of financial mechanisms, and an overemphasis on lower-value actions in the R hierarchy.

As for how EU capital cities incorporate stakeholder engagement into their CE strategies (RQ2), our study shows that only half of the strategies explicitly describe stakeholder engagement. Moreover, the depth, quality, and influence of these participatory processes remain uneven, with many cities providing only nominal or generic involvement. These findings underscore that, while lessons can be drawn from cities with more transparent and inclusive approaches, there is still a need to strengthen participatory governance, enhance accountability, and embed social and equity considerations in CE strategies.

Some limitations of this study have nevertheless to be acknowledged. It focuses only on the 10 EU capital cities that have published CE strategies, which means that the findings might not be representative of all EU capitals, and that some high-profile capitals such as London (outside the EU) and Stockholm or Berlin (without standalone CE strategies) are not included. The analysis is also based solely on publicly available documents and does not account for CE initiatives embedded in other policy documents, such as climate adaptation or waste management strategies. This was a methodological choice to ensure consistency, allowing for meaningful cross-city comparison, as the study offers a broad view of the current state of CE strategy development in EU capitals and highlights the need for more robust, transparent, and inclusive approaches. Nevertheless, the framework developed here could be applied to other urban and regional contexts, to assess the evolution of CE strategies globally.

In conclusion, understanding the political, institutional, and cultural drivers behind CE strategy design is critical for improving future implementation and upscaling best practices across cities. In particular, this study underscores the need for a more holistic and inclusive approach to CE planning in cities, one that not only integrates technical and environmental considerations but also prioritizes participatory governance, and long-term institutional capacity.

6. Conclusions

This study analysed the CE strategies of 10 EU capital cities, to identify key trends in urban CE planning and to explore what lessons can be drawn from current practices. Despite the European Commission's CE Action Plan being introduced in 2015, only a limited number of capital cities have since developed standalone CE strategies, most of them emerging after 2019. Moreover, while these efforts reflect a growing commitment to circularity at the local level, the analysis reveals that many existing strategies lack the robustness and transformative ambition required to realise the vision of a just and sustainable circular city.

Drawing on an integrated literature review, the study developed and applied an analytical framework to assess CE strategies. This led to the creation of a typology comprising three types of strategies: Robust Strategies, which are the most transparent, engage stakeholders actively, and assign responsibility for actions, though they often lack detailed financial planning; Moderate Strategies, which exhibit partial transparency and some stakeholder engagement, but fall short in methodological consistency and depth; Basic Strategies, which provide minimal detail on methodology, participation, or accountability, indicating symbolic rather than substantive governance efforts. This offers an operational framework that links strategic quality to participatory depth and methodological rigour. In doing so, it helps bridge the gap between CE ambition and institutional implementation.

The findings of this study suggest that variation in CE strategy development is not solely driven by economic capacity or environmental ambition, but also by governance cultures, levels of municipal autonomy,

and external collaborations. While most of the analysed strategies address environmental and governance priorities, most predominantly contain lower-value circular actions (such as recycling and reusing), and many fail to meaningfully incorporate stakeholder perspectives or local socio-economic realities. This disconnect risks limiting the relevance and effectiveness of CE initiatives, particularly in contexts where community engagement is essential for legitimacy and impact. For policymakers, this therefore highlights the need to invest not only in infrastructure and technology but also in participatory governance structures and international collaborations that expand institutional learning and resources.

Our study advances the academic literature, by offering both a conceptual and empirical contribution to the understanding of how CE strategies are being articulated in EU capital cities. It provides a replicable tool for evaluating urban CE strategies, contributing a practical lens for both academic inquiry and policy assessment. For policymakers, it underscores the need to complement infrastructure investments with participatory governance structures, stakeholder inclusion, and cross-sectoral collaboration. For practitioners, including particularly urban and policy designers, the findings provide actionable insights into the elements of more effective and accountable CE strategies.

Future research should extend the analysis beyond capital cities, test the proposed typology in a wider range of geographical and governance contexts, and conduct longitudinal studies to assess the long-term outcomes of CE strategies. In-depth qualitative investigations, such as interviews with policy designers, local actors, and civil society stakeholders, could yield deeper insights into the political and institutional dynamics of CE implementation.

Overall, although the adoption of CE strategies at the city level is growing, many remain fragile and technocratic, with insufficient participation. To bridge the gap between ambition and implementation, cities thus must move beyond symbolic planning and invest in inclusive, well-resourced and accountable pathways to circularity. In particular, it is crucial to address persistent gaps in stakeholder engagement, social equity, and the prioritisation of high-value circular actions, in order to realise the full potential of the CE as a driver of sustainable and just urban transformation.

Author Contributions Lourenço Booth: Conceptualization; Research; Data curation; Formal analysis; Investigation; Methodology; Writing - original draft. Paula Antunes: Supervision; Writing - review & editing; Validation Ana Jesus: Supervision; Writing - review & editing; Validation. All authors have read and agreed to the published version of the manuscript.

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Data Availability The data supporting the findings of this study consist of publicly available documents. All documents cited in the manuscript can be accessed through the official institutional websites of each city. No proprietary, confidential, or personal data was used. The processed data underlying the analytical framework and typology (including coding tables and comparative assessments) can be made available from the corresponding author upon request by email.

Declarations

Competing interests The authors declare no competing interests.

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Annexures

Annex 1. Criteria for the four pillars of sustainable development

For the attribute "Relevance to sustainable development", we adapted the work done by Papageorgiou et al., (2021), Chao et al., (2020) and Tampouridou & Pozoukidou (2018) using the criteria mentioned in Table 6. This attribute is intended to assess each action of the strategy individually, by determining to which pillar they would be most relevant (Environmental, Social, Economic or Governance).

Table 6. Criteria for the four pillars of sustainable development.

Environmental	Social	Economic	Governance
Material consumption	Housing	Economic growth	Public administration
Water consumption	Health and wellbeing	Investment	Public procurement
Energy consumption	Safety	Added value	Planning
Efficiency	Education	Revenue & Income	Regulations
Solid waste	Employment	Costs	Strategies
Wastewater	Public spaces quality	Savings	Stakeholder engagement
Air pollution	Equity	Entrepreneurship	Awareness raising
Water pollution	Poverty	Productivity	Collaboration
Soil pollution	Active citizen participation	Self-sufficiency	
Climate change	Social inclusion		
Biodiversity			
Green spaces			
Land use			

Annex 2. Criteria used for the R hierarchy

The attribute "R hierarchy" was adapted from Fornasari & Neri (2022), and it evaluates the alignment of each action or measure proposed with the 10R hierarchy (Reuse, Repair, Reduce, Recycle, Refuse, Rethink, Refurbish, Remanufacture, Repurpose, Recover). Each action from each city's strategy was assessed to determine which R it would refer to, using the criteria provided in Table 7.

Table 7. Criteria used for the R hierarchy

R hierarchy	Criteria of assessment
Reuse	Conceive of new products with components that can be reused in other contests
Repair	Build products that are easy to repair, so they do not need to be replaced in case of failure.
Reduce	Reduce consumption of energy and materials during the life cycle of the product.
Recycle	Use recyclable materials for new products, and design products so that they can be easily recycled at the end of the life.
Refuse	Replace substances dangerous to humans or the environment with safer alternatives.
Rethink	Conceive of products and their functions in a new way, so that they can be produced and used more efficiently
Refurbish	Repair, repaint, and redecorate products to make them look new again.
Remanufacture	Rebuild products using a combination of reused, repaired and new components.
Repurpose	Find new use for products.
Recover	Restore products to become functional again after being damaged or encountering problems.

Annex 3. Typology classification rubric per city

Table 8. Typology classification rubric per city

City	Methodology Clarity	Stakeholder Engagement	Accountability Measures	Score	Type
Amsterdam	2	2	2	6	Robust
Helsinki	2	2	2	6	Robust
Prague	2	2	2	6	Robust
Tallinn	2	2	1	5	Robust
Paris	1	2	1	4	Moderate
Ljubljana	1	1	2	4	Moderate
Brussels	1	1	1	3	Moderate
Bratislava	1	0	1	2	Basic
Madrid	0	0	1	1	Basic
Copenhagen	0	0	0	0	Basic

Criteria:
Absent: 0
Partial addressed: 1
Clearly addressed: 2