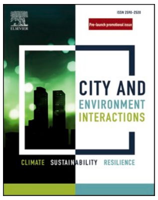
City and Environment Interactions 28 (2025) 100261

Contents lists available at ScienceDirect

City and Environment Interactions

journal homepage: www.sciencedirect.com/journal/city-and-environment-interactions



Review Articles

What will a circular city look like? A systematic literature review of urban circular economy applications and their implications for research and practice

Alexandre Coussa [1]

University of Fribourg, Department of Economics, Center for Competitiveness

ARTICLE INFO

Keywords:
Circular Economy
Urban Circular Economy
Circular cities
Circular Applications
Circular Policies
Urban Policies

ABSTRACT

This review explores Circular Economy (CE) applications in urban contexts and their implications for practice, and research. By making sense of concrete challenges of implementing the urban circular economy (UCE) and creating circular value in urban areas, this article addresses an important but under-explored gap in the literature, providing solid foundations for understanding UCE applications and related value creation. The paper follows a systematic review following PRISMA guidelines. First through keywords mapping, four main research axes are identified: waste management, new forms of urbanity, green ecosystems, and circular governance. Those are then reviewed through a content analysis of 135 articles that make sense of their applications and main issues. Lastly finding' implications are examined using various theoretical lenses, including CE classification, circular business models (CBM), institutional theories, sustainability transition theory (STT), and industrial ecology (IE). Overall, the article identifies promising but understudied areas, such as economics, business models, and urban studies, meanwhile research in the "hard sciences" is very active. UCE applications span from low-value technocratic fixes to more transformative initiatives. While many mitigate urban externalities and contribute to address global change issues, others aim to reshape urban paradigms but often lack scalability. Another challenge for cities will be to move towards high-value CE strategies, develop urban CBMs, overcome systemic barriers, and integrate inclusive governance and resilience into urban design. To achieve a scalable and regenerative urban future, UCE will need to be advanced through more in-depth research, supportive policies, and systemic changes in knowledge, behaviors, and urban construction practices.

Introduction

In recent years, the concept of the circular economy (CE) has garnered increasing attention from researchers, policymakers, and businesses actors [1,2]. This interest stems from a desire to decisively shift from linear models of the economy to circular ones [3]. This desire is rooted in the imperative to reduce the environmental footprint of human activity, while simultaneously promoting new production and consumption models that minimize resource consumption and create economic, environmental, and social added value.

Although there is no universally accepted definition of the CE [4]), the definition proposed by the Ellen MacArthur Foundation (EMAF) is often considered as a reference, due to the foundation's prominent role in the field [5]. The EMAF [6] defines the CE as a system that addresses climate and decouples economic activities from resources by avoiding making waste from materials and regenerating natural ecosystems; in such systems, products and resources remain in circulation through maintenance, reuse, refurbishment, remanufacturing, recycling, and composting. Its purpose is to contribute to more sustainable patterns of production and consumption by implementing strategies based on three main approaches: (1) smarter product use and manufacturing, (2) extended product or component lifespans, and (3) improved reuse, recovery, and recycling of product materials [7,8].

With around 60 % of the world population now living in urban areas, 50 % of global waste, 75 % of global greenhouse gas (GHG) emissions and security concerns arising from growing resources consumption, cities have become crucial sites for effectively developing sustainable policies and improving the quality of life for as many people as possible [9,10]. In recent decades, many cities, particularly in China and Europe, have developed strategies to increase sector-specific or general

---

E-mail address: alexandre.coussa@unifr.ch.

[1] Orcid: (0000-0003-1845-672X).

https://doi.org/10.1016/j.cacint.2025.100261
Received 25 August 2025; Received in revised form 13 October 2025; Accepted 29 October 2025

circularity. However, these initiatives have sometimes lacked a consistent understanding of what CE and urban circular economy (UCE) entails [11]. During the same period, research on UCE applications has experienced a rapid growth, accompanied by a diversification and overlap of related concepts [12].

CE can play an important role in urban areas by ensuring their competitiveness while contributing to closing the loop of inner production and supporting long-term sustainability and resilience [13]. In addition to positive environmental and economic outcomes, CE contributes to enhancing the quality of life of urban dwellers thereby generating public value, although it remains a long-term process that requires stakeholders to learn about the CE, and local authorities to better integrate it into the decision-making process [14,9].

Although there are studies on the UCE, to the author's knowledge, none comprehensively make sense of how CE is implemented in cities. As shown in Table 1, based on a Google Scholar search, which presents a non-exhaustive list of literature reviews with a cities perspective, there is a noticeable gap in research specifically addressing the question of CE in urban areas. Consequently, reviewing the literature to understand how CE is implemented represents a meaningful and timely research gap that warrants attention that might contribute to understanding UCE applications on a comprehensive perspective, their value for cities and the mains implications.

Such research responds to an already identified issue which is that CE potential benefits in urban contexts are often not fully recognized or understood by local actors [13]. Understanding CE application in urban spaces is, however, an important aspect of strategic development because it helps to identify what type of value is generated by which projects or decisions, which stakeholders benefit from it and how practitioners might ultimately better allocate their resources and adapt their decision-making [21,22]. These include consumers, policymakers, urban planners, and educational institutions, all of whom are instrumental in promoting sustainable behaviors, fostering innovation, shaping circular policies, and creating the infrastructure and ecosystems necessary for CE development.

Furthermore, in such context where CE becomes a strategic priority and response to the numerous global crisis faced today [23], understanding economic, technological and environmental interactions will become of first importance as their interplay strongly contribute to CE development, especially through infrastructure and technological advancements [24]. Since urban areas are central to sustainable transition, they will continue to play a key role in shaping a circular, sustainable future. According to Williams [10], the principle of reducing waste and resource consumption, preserving natural capital and ecosystem, and designing out negative externalities should gain importance in current conceptions of closed-loop industrial systems, circular businesses and cities' provision systems. Moreover, scholars show also that in order to accelerate circular transition, coordinated and region-specific approaches become crucial as local disparities and factors strongly influence CE public policies[25].

Table 1
Non-exhaustive summary of main reviews done on uce.

Authors (year)	Title	Subjects/Focus
Dindarian [15]	Overview: The smart sustainable city initiatives and the circular economy	Smart city applications related to sustainability and CE
Shahin and Alimohammadlou [12]	Current status and emerging trends on urban circular economy: a bibliometric analysis	Bibliometric analysis of UCE publications
Murthy and Ramakrishna [16]	A review on global e-waste management: urban mining towards a sustainable future and circular economy	Review best practices in E-WM and urban mining to favor CE development
Tsui et al. [17]	The role of urban manufacturing for a circular economy in cities	Urban manufacturing role in CE
Petit-Boix and Leipold [18]	Circular economy in cities: Reviewing how environmental research aligns with local practices	Review of cities circular initiatives considering environmental research
Joensuu et al. [19]	Circular economy practices in the built environment	Understand views of the literature on CE transition in cities
Vanhuyse et al. [20]	The lack of social impact considerations in transitioning towards urban circular economies: a scoping review	Social impacts (culture, health and fears and aspirations) of CE in cities

Therefore, these considerations open an important debate about how cities should implement CE and this review aims accordingly to systematically analyze the integration of CE in urban context, focusing on its concrete applications and policy implications. Accordingly, the research questions (RQ) guiding this study are as follows:

RQ 1: What are the main topics of the academic literature on CE at the level of municipalities?

RQ 2: What are the CE applications at the level of municipalities?

RQ 3: What are the main implications associated with UCE applications?

To do so, we conduct a keywords mapping of CE literature focused on urban contexts, based on articles published between 2015 and 2024 and indexed in the Web of Science (WoS) database. This is followed by a content analysis of 129 articles which examine the primary applications, strategic axes, and associated value creation. Finally, the implications for practitioners, policymakers and research are discussed.

Answering these RQ through a review of the literature helps local authorities and stakeholders better understand the value CE generates in urban areas and gain a comprehensive overview of the UCE and policy stakes associated with its development. For scholars, the contribution of this paper will be to better frame the particularities of CE in municipalities, identify the gap in the literature to raise accurate new research questions and understand how their research integrates the overall stake of developing CE in cities.

The remainder of the paper is organized as follows. Section 2 presents the research framework and methodology. Section 3 presents the results of the keywords analysis (RQ1) and the findings from the content analysis (RQ2). Section 4 discusses the practitioners, policy and research implications (RQ3). Section 5 concludes the paper and discusses its limitations.

Research framework and methodology

This section outlines the research framework and questions. It also describes the process of selecting articles as well as their bibliometric and content analysis.

Research framework

Building on the gap identified in Section 2, this study addresses the critical need for understanding CE applications in urban areas and their associated value creation and implications. Despite the growing body of research on UCE, the issue of value creation has not yet been systematically examined and structured. Consequently, the first RQ is:

RQ 1: What are the main topics of the academic literature on CE at the level of municipalities?

To address this question, the main research topics are identified through a mapping of the authors' keywords. This approach provides a clearer understanding of the research context and its key themes. Secondly, it is essential to examine the UCE applications themselves. Therefore, we propose the second RQ:

RQ 2: What are CE applications at the level of municipalities?

Answering this question involves identifying, within the main research topics, the key axes and applications of the CE in the urban context. This requires a deeper understanding of what the main CE applications are and how these applications create value. Once the UCE applications are identified and their associated value understood, it becomes essential to explore the implications for involved policy-makers, researchers and practitioners. Therefore, we formulate the third RQ as follows:

RQ 3: What are the main implications associated with UCE applications?

This question is addressed by applying theoretical lenses to frame the analysis and derive meaningful recommendations accordingly. The iterative research framework is illustrated in Fig. 1. It begins with the selection of relevant articles from a scientific database, following the PRISMA guidelines. The PRISMA guidelines are a standardized set of procedures designed to enhance the transparency, completeness, and reproducibility of systematic reviews[26]. This codified process is reproduced in the present study and depicted in Fig. 1, thereby strengthening the credibility and replicability of the review.

Once the data is collected, a bibliometric analysis is conducted to address RQ1, providing a comprehensive overview of the key thematic trends. Building on this mapping, the identified topics are structured into key axes and further examined through a content review of selected articles to explore concrete CE applications in urban contexts (RQ2). The findings are then synthesized in the discussion section, where the policy, strategic, and academic implications (RQ3) are critically analyzed. Finally, complementary searches are performed to broaden the global and technological perspectives of the study.

Methodology

Data extraction

To gather articles in a systematic manner which avoid authors' bias and ensure a wide coverage of the relevant literature, WebofScience (WoS) database had been chosen since WoS is one of the major sources

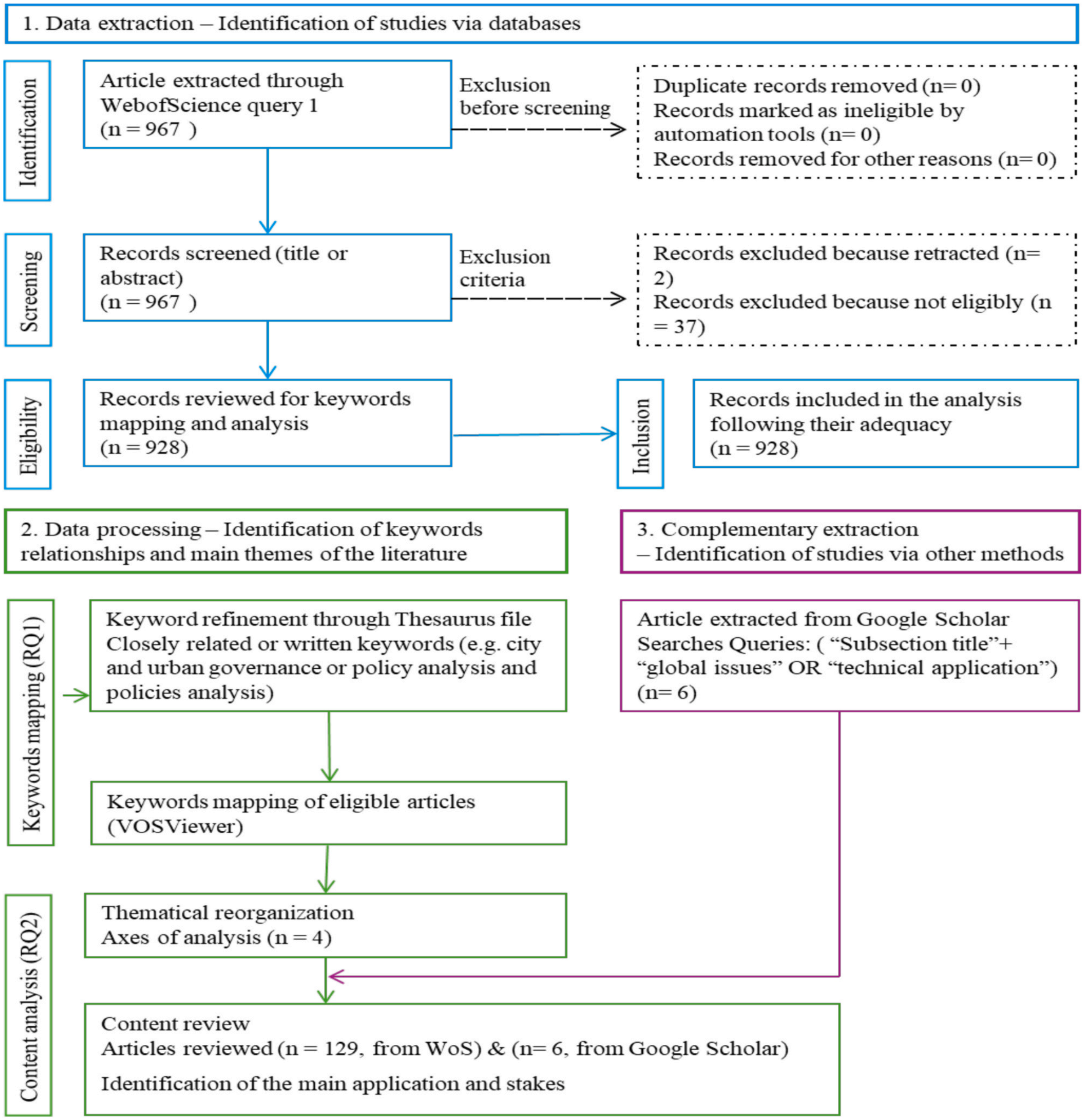


Fig. 1. Research framework.

of scientific publications[27].

Query 1: ((TI=(circular*)) AND (TI=(cities) OR TI=(city) OR TI=(municipalit*) OR TI=(urban)) OR (AK=(circular*)) AND (AK=(cities) OR AK=(city) OR AK=(municipalit*) OR AK=(urban)) OR (AK=(circular*)) AND (TI=(cities) OR TI=(city) OR TI=(municipalit*) OR TI=(urban)) OR (TI=(circular*)) AND (AK=(cities) OR AK=(city) OR AK=(municipalit*) OR AK=(urban)) AND DT=(Article OR Review)).

The specification used to gather articles is presented in Query 1. The initial search was conducted mid-December 2024. The search terms used included the title and keywords containing the term "circular*" to have articles discussing CE with more flexibility as it encompasses close notions such as "circularity" or "circular city". Other denominations related to CE such as "closed loop" were considered but not included since prior bibliometrics only used terms "circular economy" or "circular" e.g. [1,27].

We combined this core term with title and keyword terms related to urban components, such as "urban", "municipalit*", "city" or "cities". We selected only peer-reviewed articles written in English during the 10 previous years, namely, the period going from 2015 to 2024 (including early access). The abstracts of the articles were excluded from the search to avoid retrieving studies that included the search terms without reflecting the intended focus. This situation can occur, for instance, when an abstract contains terms such as circular, cities, or urban but does not actually address topics related to the CE in urban contexts. Including such records could have resulted in an excessively large and inconsistent dataset, making screening and analysis inefficient.

Moreover, because the search terms targeted the intersection between CE and urban contexts, some studies discussing CE issues from global or technological perspectives may have been omitted, even though they could contribute valuable insights to the academic debate on UCE. Therefore, in accordance with the PRISMA guidelines, additional relevant articles were incorporated using a complementary method. In this study, this process involved a narrative review conducted through the Google Scholar database, where, for each subsection, the terms related to the subsection title were combined with either the terms "global issues" or "technological applications".

However, as illustrated in Fig. 1, these additional articles were not included in the mapping of UCE applications, since they do not directly inform this research question. Instead, they were used throughout the review to provide broader perspectives on the identified topics and to situate the UCE literature within a more global and technological context.

Data processing.

The initial search in the WoS database yielded 967 articles. In a subsequent screening step, 37 articles were removed because they did not align with the objectives of the analysis. These records appeared in the database as they contained the search terms but were unrelated to the topic of the UCE—for example, papers addressing *circular polarization in urban space* or *rural–urban circular migration*. In addition, two retracted articles were excluded. Consequently, a total of 39 articles were removed, resulting in a final dataset of 928 articles.

Once the articles were gathered, a bibliometric analysis was conducted. In this study, the authors' keywords retrieved from WoS were analyzed using VOSviewer and Microsoft Excel. Data cleaning was performed using thesaurus files to eliminate duplicates and merge closely related or differently written keywords, as recommended by Van Eck and Waltaman [28].

After generating the keyword mapping, the terms identified in Fig. 2 were filtered in Excel. For each main keyword within each cluster, relevant articles were reviewed based on their titles, abstracts, citation counts (considering publication date), and overall content (see also Fig. 3).

This approach ensures a systematic, transparent, and reproducible analysis. It enables, first, a scientifically rigorous mapping of keywords, and second, a careful selection of articles to retain only those most relevant to the research questions. By following this structured process, subjectivity in the identification of sources is minimized, thereby strengthening the validity and credibility of the review.

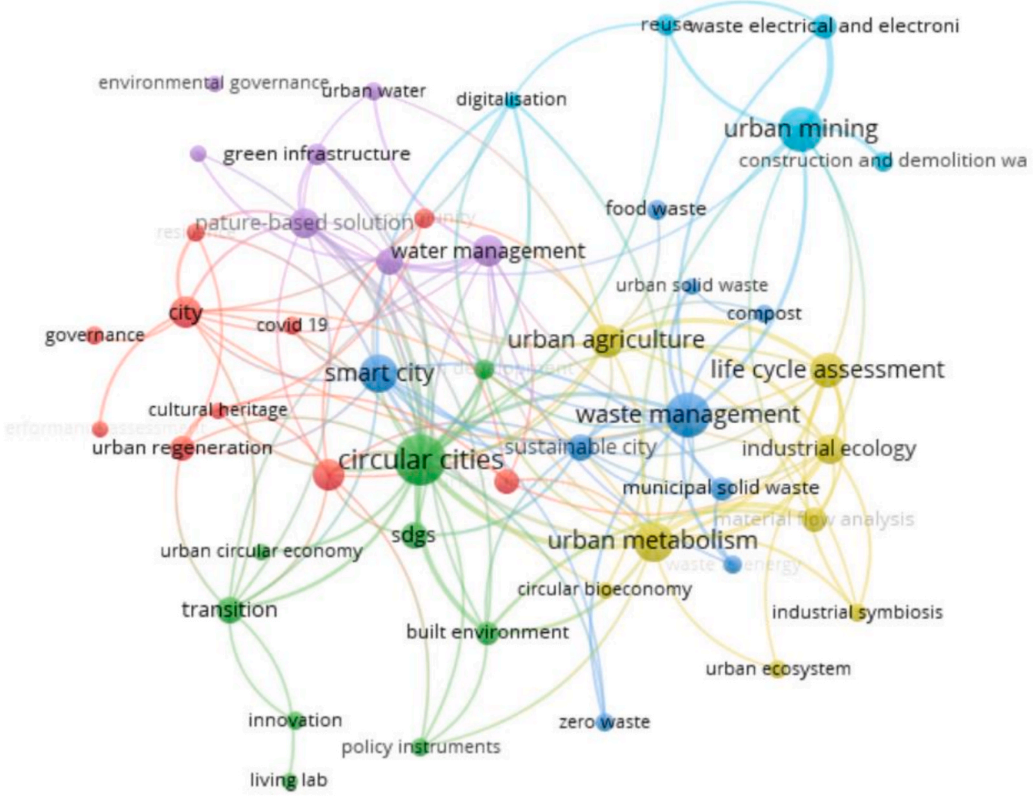
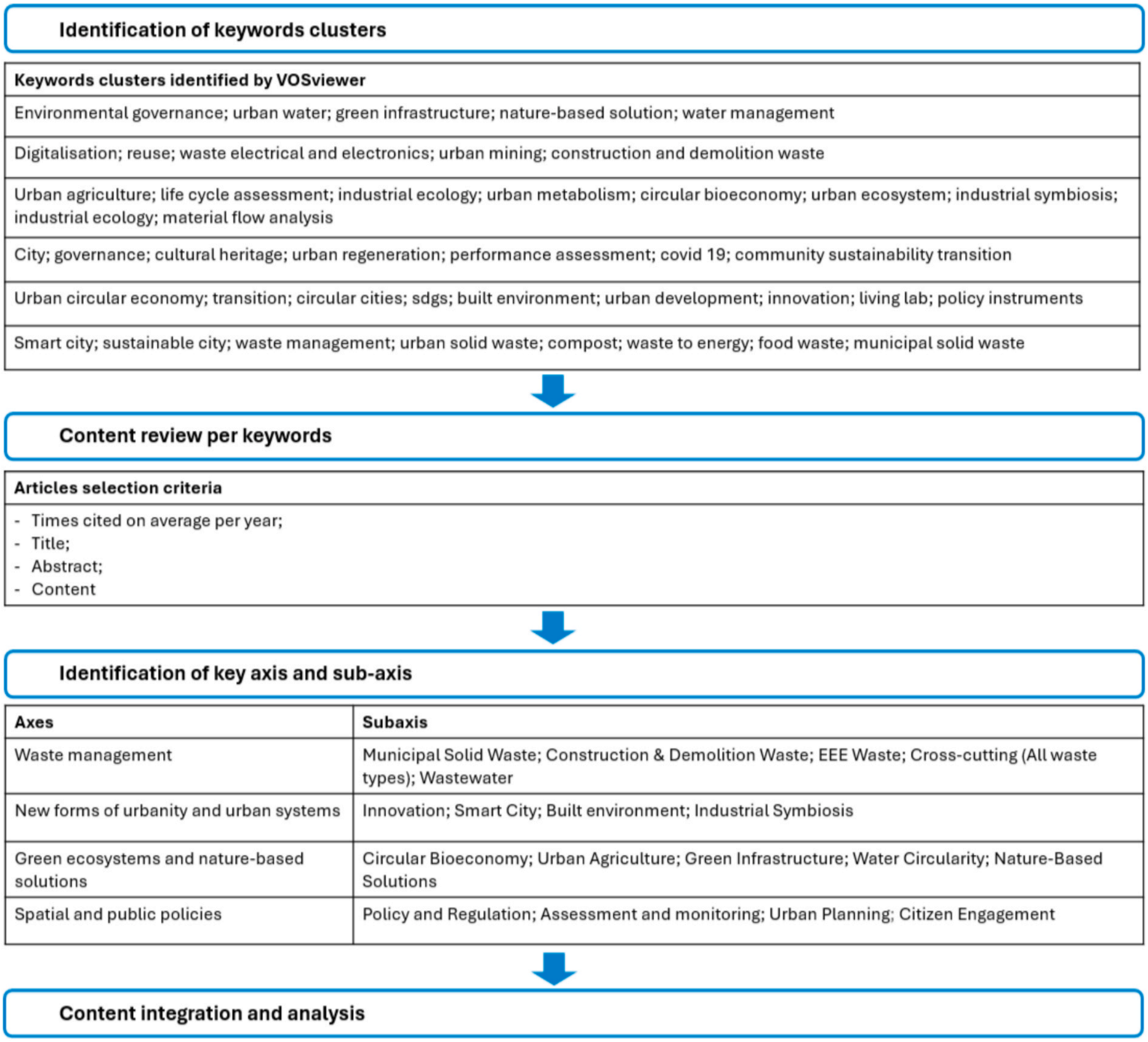


Fig. 2. Keywords occurrences and relationships.



Identification of keywords clusters

Keywords clusters identified by VOSviewer
Environmental governance; urban water; green infrastructure; nature-based solution; water management
Digitalisation; reuse; waste electrical and electronics; urban mining; construction and demolition waste
Urban agriculture; life cycle assessment; industrial ecology; urban metabolism; circular bioeconomy; urban ecosystem; industrial symbiosis; industrial ecology; material flow analysis
City; governance; cultural heritage; urban regeneration; performance assessment; covid 19; community sustainability transition
Urban circular economy; transition; circular cities; sdgs; built environment; urban development; innovation; living lab; policy instruments
Smart city; sustainable city; waste management; urban solid waste; compost; waste to energy; food waste; municipal solid waste

Content review per keywords

Articles selection criteria
- Times cited on average per year; - Title; - Abstract; - Content

Identification of key axis and sub-axis

Axes	Subaxis
Waste management	Municipal Solid Waste; Construction & Demolition Waste; EEE Waste; Cross-cutting (All waste types); Wastewater
New forms of urbanity and urban systems	Innovation; Smart City; Built environment; Industrial Symbiosis
Green ecosystems and nature-based solutions	Circular Bioeconomy; Urban Agriculture; Green Infrastructure; Water Circularity; Nature-Based Solutions
Spatial and public policies	Policy and Regulation; Assessment and monitoring; Urban Planning; Citizen Engagement

Content integration and analysis

Fig. 3. Summary of content review and axes identification process.

The applications and values of circular economy in urban contexts

Fig. 3 presents the main clusters derived from the author-provided keywords, offering insight into the thematic boundaries and interconnections within UCE research. To ensure a comprehensive overview of the field, a relatively low occurrence threshold was applied. Keywords appearing in at least nine publications (approximately 1 % of the dataset) were included. Generic terms such as “circular economy” and “bibliometric analysis” were excluded to minimize bias and better reveal underlying patterns and specific research themes. As a result, six distinct clusters comprising 48 keywords were identified. This clustering provides a clearer delineation of the major areas of research and establishes a foundation for subsequent, in-depth qualitative exploration. These six thematic clusters form the analytical basis for addressing RQ2, guiding the examination of how UCE is operationalized across the literature.

However, although these clusters help identify interlinkages between keywords and their relative strength such as for instance between urban mining and waste electrical and electronics (two strongly related topics), they do not precisely determine the main themes or axes as several keywords closely related, and supposedly from the same thematic area, can be found in multiple clusters, as is the case with waste-related topics. Conversely, some keywords are highly transversal and cannot be confined to a single cluster perspective.

For this reason, the literature was reviewed before defining the overarching axes of the study. As illustrated in Fig. 3, which outlines the process of identifying the axes and their underlying sub-axes, the content of a selection of articles corresponding to each keyword (identified in Figs. 2 and 3) was reviewed and summarized. Articles were selected based on a screening of their titles and abstracts, considering citation counts relative to publication date. The final inclusion was determined by evaluating the content of each article, considering its relevance, novelty, and methodological rigor. Consequently, the analysis was conducted on 129 articles from the initial database, complemented by six additional articles obtained through complementary searches, as described in Section 3.

Once the insights from the literature were synthesized, the analysis was reorganized along four axes, as presented in Fig. 3. These axes represent the main directions identified in the literature. Each axis is further divided into sub-thematics, corresponding to the subsections, which present concrete UCE applications and the types of value they generate. These are summarized in Table 2. The following subsections address RQ2 by providing a detailed examination of each axis, highlighting key applications and insights from the literature.

Table 2
Main axes, applications and value created by CE in urban areas.

Axes	Subaxes	Applications	Value created
Waste Management	Municipal Solid Waste	Incineration, Gasification, Flameless Oxy-combustion	Energy recovery; reduced landfilling; economic viability
		Composting (centralized/decentralized)	Reduced landfilling; soil regeneration; UA competitiveness; environmental awareness; local nutrient recovery; circular food systems
		Food waste reduction & redistribution	Economic savings, social benefits; waste minimization
	Construction & Demolition Waste	Urban mining	Material recovery; GHG reduction; raw materials resilience; urban regeneration; job creation; social wellbeing; old building valorization; economic revenue
		Building refurbishment	Regenerates disused buildings; sustains local economies; material lifespan extension.
		Use of construction excavated soil and waste	Low environmental impact alternatives; material lifespan extension; reduced landfilling
	EEE Waste	Urban mining	Supply chain resilience; product life extension; economically profitable; job creation; resource depletion limitation
	Cross-cutting (All waste types)	Digitalization, blockchain, IoT and AI solutions	Efficient separation & treatment; stakeholder engagement; job creation; improved traceability and flow control
		Smart city integration	Redesigns supply chains; predictive urban metabolism; reduces virgin material use
	Wastewater	Recycling, reuse, stormwater management	Urban water security; Reduced water imports
		Sludge valorization	Generates bioproducts; new economic activities; circularity in water sector
New forms of urbanity and urban systems	Innovation	Urban and social innovation	Transition to knowledge-based cities; economic growth, competitiveness, attractiveness, improved quality of life; citizen empowerment
		Urban Living Labs	Co-learning and creation; stakeholder engagement; scaling of niche innovations; institutional change; society learning; low-cost high-quality research; CE experimentation
		Cultural assets and civic engagement	Adequation between knowledge and policies; urban regeneration
		Circular-oriented innovation policies	Economic agglomeration; innovation; SDG alignment; environmental performance
	Smart City	Smart systems for waste collection, sorting, recycling	Less landfilling; reduced emissions; lower operational costs; diversified and risk mitigated supply-chains
		Spatial zones for CE initiatives; digital management of urban flows	Resource efficiency; optimized infrastructure investment; citizen empowerment
		IoT; machine learning; autonomous systems; data-driven CE	Predictive maintenance, waste reduction; social well-being; economic revenue; touristic attractiveness; informed planning
		Municipalities as facilitators; platforms for citizen participation; Behavioral change	Policy legitimacy; active citizenship, compliance
		Green supply chains, CBM; AI; Automation	Reduced material footprint; innovation-driven business models
		Smart Tourism	Touristic attractiveness; sustainability in transport, energy, and waste improvement
	Built environment	Reuse of materials in construction; discontinuation policies	Resource efficiency, better governance; resources recovery; cost reduction; material efficiency; sustainable resource management
		Cultural heritage reuse	Social, environmental, and economic value; underutilized spaces revitalization; city identity and cultural cohesion enhancement
		Nature-Based built solutions	Biodiversity, building insulation, better water management; environmental performance; social well-being
Green ecosystems and nature-based solutions	Industrial Symbiosis	Waste and by-product exchanges; heat recovery; EIP	Resource consumption reduction; carbon footprint; local welfare; economic revenue
	Circular Bioeconomy	Valorization of bio-resources; integrated urban systems	Resource recovery; reduced emissions; new CBM; tech innovation conversion; economic development
	Urban Agriculture	Hydroponics, vertical farming, rooftop farming, aquaponics	Food security, resource efficiency, GHG reduction, social inclusion, local empowerment, reduced logistics
	Water Circularity	Wastewater reuse; storm/rainwater capture; decentralized systems	Water conservation, urban resilience, reduced infrastructure needs, creation of economic value from low-value flows
	Green Infrastructure	Green roofs, wetlands, pervious surfaces, tree cover	GHG reduction, biodiversity, air purification, microclimate improvement, stormwater control
	Nature-Based Solutions	Bioconnectivity; GI; CBM	Regenerative urban systems, social well-being, public engagement, ecosystem restoration; biodiversity conservation
Spatial and public policies	Policy and Regulation	UCE frameworks, CBM promotion; (non) digital platforms	Environmental performance; regulatory clarity; SDG alignment; market transformation, resource efficiency
	Assessment and monitoring	LCA; MFA/MEFA; public disclosure; CE indicators	Informed decision-making; systemic evaluation; Environmental performance; governance effectiveness, transparency
	Urban Planning	CE-integrated land use; IS; FDI; CE incentives	Innovation, infrastructure optimization; Economic competitiveness, job creation
	Citizen Engagement	Co-design, participatory spaces	Social innovation, behavioral change; CBM demand

Note: the abbreviations used can be found in the table of abbreviations in the appendix.

The challenge of waste management in cities

WM is one critical issue for cities, as growing demographics, urbanization, and industrialization pressure existing systems, leading in case of poor management to negative economic, social, environmental, and technical consequences [29]. The waste streams having garnered substantial attention in literature are municipal solid waste (MSW), construction and demolition waste (CDW), and electrical and electronic equipment waste (EEEW). Cities stand at the forefront of these challenges but also offer different solutions and opportunities resulting CE applications, reframing waste not merely as a byproduct, but as a resource, fostering new practices like urban mining or waste recovery [30].

The circular applications to municipal solid waste.

MSW represents the first major category of waste generated in urban areas, largely due to high population density and the concentration of human activities. Commonly referred to as garbage, it consists of non-hazardous disposable materials produced by households, institutions, and enterprises. Within linear economic systems, MSW is traditionally managed through landfilling.

A classic solution to substitute waste landfilling is the incineration of waste to produce energy (WTE). Colangelo et al. [31] compare three WTE technologies, namely incineration, gasification, and flameless oxy-combustion, while integrating carbon pricing, and find that while gasification currently appears most sustainable, oxy-combustion may become more attractive as carbon pricing increases. Similarly, [32] suggest that WTE systems can satisfy between 1.4 % and 3.6 % of electricity demand in global cities under economically viable conditions. Nonetheless WTE processes still pose pollution and toxicity risks, and may hinder the circular re-entry of materials into production cycles [33,34].

Moreover, even within landfilling practices, research shows that certain CE principles—such as the recovery of energy, heat, and electricity from emitted gases like methane and carbon dioxide—can be applied. These practices contribute to climate change mitigation, generate positive socioeconomic outcomes, and support energy production. However, such applications require careful assessment and further investigation, as they remain associated with notable environmental impacts [35,36].

A promising alternative to WTE and landfilling is composting which implies the separation of organic and non-organic waste and which is inexpensive and easily adoptable by communities [33]. Its positive effects should not be underestimated, as decentralized composting can divert up to 50 % of waste from landfills, treat waste in a more environmentally responsible manner, restore soil health through circular nutrient cycles, and promote environmental awareness [37]. Decentralized composting can be integrated into urban agriculture (UA), improving at low-cost farmers competitiveness, nutrients recovery from MSW and enhances circularity and urban food systems on a small geographic scale [38,39]. Moreover, community-based composting initiatives serve as platforms to build a new imaginary and sensibilize to CE transition, practices and care, scaling up sustainable transition [40].

Food waste within MSW has also gained scholarly attention. Applications in the realm see food waste potential to supply important quantities of nutrients for local UA developing a circular system at local scale [41,42]. Moreover, food WM policies impact has been studied by Parsa et al. [43] in city of Bristol, showcasing that among seven options studied (food waste reduction, redistribution, animal feed, anaerobic digestion, composting, incineration, or landfilling), this is the reduction of food waste in households, food services and hospitality, as well as it redistribution in supply sector that provide the better environmental, social and economic outcomes.

Urban mining for construction and demolition and electrical and electronic equipment wastes.

A growing concept associated with the urban circular economy (UCE) is urban mining, which in the literature is applied almost exclusively to CDW and EEEW. According to reviews of current and future perspectives on urban mining, the concept involves viewing end-of-life stocks of CDW and EEEW as reservoirs of valuable resources that can be “mined” and recovered in the future. In this way, urban mining serves as a potential source of employment, energy, materials, and well-being, while simultaneously addressing high resource consumption rates and related environmental challenges [30]. Urban mining aligns therefore strongly with United Nation Sustainable Development Goals (SDG) and tackles two important sources of waste in urban areas which are EEEW and CDW while benefiting from the last technological advances [44].

When it comes to articles focusing on the applications and potential of urban mining specifically to CDW, research highlights the potential to reduce raw material extraction, transportation, carbon dioxide emissions, and landfill dependency e.g. [45,46]. In this context, rather than viewing the built environment as merely functional, urban mining repositions it as a material stock to support CE goals, closing the loop of heavily polluting construction activities [47,48]. Refurbishment of old buildings is discussed by Luciano et al. [46] whose material flow analysis suggests that it can value disused buildings, contributing to urban regeneration and cities’ material stocks. Another application proposed is to use urban biowaste and excavated soil since they have low environmental impact but still good performances and availability [49].

EEEW presents similar potential. In London, its recycling contributes to urban resilience and diversified supply chains [50]. Furthermore, local EEEW mining helps to reduce reliance on raw materials and cuts down on environmental damage [51,52] and strengthens cities resilience and sustainable [53]. According to Shittu et al. [54] 97 % of small EEEW from an urban mine in the United Kingdom was reusable and that there lifespan could be thus extended. Peiró et al. [55] further emphasize that extracting and separating electronical components such as hard disk drives is economically profitable and should be promoted.

The new applications for waste management through digitalization and smartness.

In the literature, WM issues are often linked to digitalization and smart technologies, underscoring the importance of digital applications in advancing circular waste practices. A review of digitally oriented circular initiatives in European cities highlights that digitalization takes multiple forms, including monitoring devices (such as Global Positioning Systems, smart grids, and trackers) to control waste and mobility flows, as well as policy-oriented applications designed to improve communication and stakeholder participation. These initiatives collectively promote multi-level, decentralized, and participatory governance [56,57]. In his analysis of sustainable transition of Tampere, Anttiroiko [58] distinguishes three layers to the transition, among them digitalization which is considered by the author as an enabler of smartness of cities which make better sense of data while improving urban metabolism or flow management. Other applications include AI and robotics for precision sorting and recycling, reducing landfilling while generating new jobs [59]and blockchain-based traceability for waste streams and stakeholder accountability [60]. Additionally, Internet and Communication Technology (ICT) tools improve CDW management by enhancing data integration and modeling[61].

Finally, Lekan and Rogers [62] discuss the social effects of digitalization in socio-ecological transformation of urban areas and argue that such tools empower, connect and integrate citizens in their communities, favor knowledge exchange, sustainable practices but presents also the risk of reinforcing existing urban social inequalities. Moreover, WM remains a crucial component of urban development, which cannot be dismissed by smart cities’ ambitions [63]. Indeed, a review of the literature highlighted that smart technologies can completely transform cities’ waste and supply chain’s flow for instance by developing integrative processes and rethinking the supply chain[64]. Developing digitalization in WM corresponds to a need of economic and technological requirements and can contribute to reduce the consumption of virgin materials by 25 % in 2030 [65]. Esmaeilian et al. [63], propose a WM framework based on smart city approach that is structured around three axes, namely infrastructure for the collection of product lifecycle data, data-based business models (BM) to prevent waste generation, and intelligent sensor-based infrastructure for upstream waste separation and collection.

Wastewater management amidst water issues.

In the context of UCE, wastewater management emerges as a major challenge. As Li et al. [66] note, climate change is expected to increase pressure on cities by reducing water availability and intensifying flooding, while also directly affecting wastewater infrastructure through overflow, breakage, and corrosion. This underscores the urgent need for urban areas to implement adaptation strategies. According to a review of city-level CE actions, approximately 59 % of cities are undertaking stormwater management initiatives, 56 % are investing in wastewater reuse, and 54.7 % are upgrading treatment systems. These efforts aim to enhance water reuse and recycling, manage rain and meltwater runoff, and facilitate nutrient recovery and wastewater circularity [67]. Moreover, another potential in wastewater CE lays in the valorization of sludge which can be used in materials and energy recovery through biorefinery, biogas and the recovery of nutrients, heavy metals, enzymes bioplastics and other composites [68]. Kehrein et al. [69] advocate for the development of "water resource factories"—facilities that leverage advanced technologies to treat wastewater as a source of economic value, thereby simultaneously contributing to CE goals and mitigating water stress. Other solutions for wastewater treatment stem out of nature-based solutions (NBS) like trickling filter, constructed wetlands and algal ponds that can treat wastewater while being environmentally and economically performant [70]. In sum the implementation of CE principles in wastewater management through the development of reuse and reclamation increases water availability, mitigates the risks for human health, and deliver valuable resources while reducing energy consumption [71].

Rethinking cities in light of urban circular economy

The transition toward sustainable urban futures hinges on the development of innovation and smartness into cities and the reconsideration of their built environment.

Innovation as necessary drivers.

Urban innovation plays a pivotal role in transforming industrial cities into knowledge-based economies. Taking the case of the cities of Helsinki, Melbourne and Hsinchu, innovation enhances economic competitiveness and attractiveness, improve the quality of life and foster cultural development [72]. Moreover, by studying in Chinese cities the relationship between urban innovation capability and cities' CE performance, Chen et al. [73] show that innovation improves livelihoods, clean energy development, industrial structures, and agricultural productivity. Social innovation also emerges as a relevant dimension. Grounded in cultural assets and civic engagement, it bridges gaps between formal policy and grassroots knowledge [74,75]. Moreover, innovation is often catalyzed by circular-oriented policies that foster governmental involvement and economic clustering, creating favorable environments for experimentation and innovation [76,77]. Innovation aligns therefore with SDG of decarbonizing the cities, especially thanks to the role of research and education institutions which contribute to develop and integrate new technologies but also develop new forms of governance and social participation [78].

Urban living labs and built environment reconsiderations.

Urban living labs (ULL) serve as experimental arenas within cities to co-create and test innovative circular solutions. ULL are spaces within cities where urban communities can experiment, develop, and implement innovative solutions paving the way to the transition of cities and CE innovative systems [79,80]. They span a wide range of domains, including WM, service innovation, and sustainable construction e.g. [81,82]. In Tampere, ULL have demonstrated their capacity to foster co-learning and transformation although the timeframe for bringing about concrete institutional changes and urban transformation remains long. [82]. A case study in Rotterdam shows that ULL contribute to the diffusion of CE-oriented services by bringing niche innovations into established practices, leading to a better transition of urban areas while tackling the critical scalability issue [83]. Finally, ULL can also be linked to universities and favor the learning of students, offering to society at low-cost, high-quality and transdisciplinary research [81,84].

The built environment is another key component in the transition toward circular cities. However, a review of the existing research reveals a predominant focus on recycling, which offers a too narrow perspective that does not fully address UCE transformation complexity [85]. The circularity of the construction sector consist mainly of the reuse of material coming from end-of-life buildings such as residential building, as studied by Arora et al. [86,87] who argue that material stock analysis of all components of building and not only metals components can serve to optimize the assessment and management of urban materials potentiality as second resources and be reused to develop new low-cost buildings. For Isoaho and Valkama [88], the application of circular policies in urban fields predominantly focus on innovation policies while discontinuation policies, namely informational, economic, contractual, regulatory, and ownership-based policy instruments could more efficiently contribute to resource efficiency of built environment. Another aspect of the built environment in literature relates to how NBS contribute to CE in urban space. An analysis of stakeholders' perceptions of NBS through semi-structured interviews in European cities suggests that built environment is one application of NBS which promote biodiversity hotspot and isolate buildings[89]. In other studies, on NBS, Pearlmutter et al. [90]; 2020) assess the inputs of practices such as green buildings systems, materials and sites that contribute to close water cycle and maximize greywater reuse in cities, mitigate negative effects of construction activities as well as indoor and outdoor dwellers actions.

Finally, cultural heritage can be reused and adapted to support the CE by reconnecting citizens with their heritage and regenerating underutilized or abandoned spaces, creating environmental, economic, and social value within cities [91,92]. Another contribution of cultural heritage lies in its positive association with the creative and circular dynamics of cities, which enhances both well-being and economic performance [93]. Nonetheless, despite these promising environmental and social opportunities, a review of circular plans from 190 European cities reveals that, although nearly all incorporate considerations of the built environment, only seven explicitly include cultural heritage. This omission represents a missed opportunity to align CE ambitions with heritage preservation and community identity [94].

Smart city applications for circular cities.

Although digital tools are promoted in WM [63]; see also Subsection 5.1), the intersection between CE and smart city concepts extends beyond WM to include issues related to infrastructure, CBM manufacturing and supply chain management or governance as reveal by a bibliometric analysis done by Santibanez Gonzalez et al. [95].

Other strands of research on the CE and smart cities emphasize that the role of public governance in the smart and circular transition of urban areas is shaped by three key dimensions: relationality, whereby municipalities act as facilitators; spatiality, which refers to the designation of specific spaces for CE development; and digitalization, which enables cities to improve data utilization and flow management [58]. A review of digital applications across various European cities highlights that, in addition to WM, urban flows include water and energy monitoring, vehicle traffic surveillance via cameras, web platforms for goods and services sharing, and sensors for public transport tracking—all contributing to optimized urban metabolic flows and increased circular efficiency [57].

In the tourism sector, the introduction of ICT helps cities to leverage their cultural and historical components by fostering tailored and efficient visitor experiences, and by contributing to dwellers' quality of life through more sustainable transportation, energy consumption, and waste generation, enhancing cities' touristic attractiveness[96]. The development of smart city will also necessitate to develop a data-driven ecosystem which consists of applying in cities development various autonomous and collaborative objects and systems, offering a macro level management perspective for decision-makers [97].

However, CE and smart initiatives cannot succeed without social awareness. As noted by Lewandowska et al. [98] and Vardopoulos et al. [96], civic engagement is vital to aligning with the "smart people" dimension of smart city framework. Moreover, when assessing whether CE (measured by material circularity) contributes to smart city sustainability performance measured by air pollution, Dincă et al. [99] find that air pollution declines more in cities displaying better CE implementation, use of renewable energy, investments in education and policies effectiveness. The smart transition, especially regarding climate change adaptation and water management, though often costly, must be more thoroughly explored. As Koop and Van Leeuwen [100] argue, long-term value creation in cities may not necessarily come from cutting-edge technologies, but rather from the effective implementation of existing solutions, supported by robust citizen participation and governance.

Developing green ecosystems and nature-based solutions within urban areas

The third axis includes articles related to integrating the CE into urban areas through green ecosystems and NBS. The unifying theme is to integrate is to envision cities as systems that optimize material and resource flows, reflecting the natural world, where residuals are valorized rather than treated as waste [101]. Urban green ecosystems are closely linked to several global challenges, including the pressures of climate change, the instability of global supply chains—which compel cities to enhance their resilience—and the growing need for healthy, green spaces. However, these ecosystems often face disadvantages, as they occupy land that generates less direct economic value compared to commercial or industrial uses, making them relatively less competitive [102,103].

Green ecosystems applications in cities.

A first development of green urban systems takes the form of Industrial symbiosis (IS). IS research is largely based on case studies which demonstrate that IS improves environmental conditions of surroundings areas while generating economic value [104]. In this transition, the role of territories play a crucial role in developing CE and industrial ecology (IE), as local contexts are strategic [101]. Nonetheless, a review IE, CE, and energy-water-food nexus reveals that the two last are at various scales, while IE is applied rather within industrial parks [105]. This finding aligns with total site integration analysis suggesting that integrated processes enhance the synergies between urban and industrial sites by minimizing waste and maximizing end of life recovery and waste valorization through heat production [106].

Developing green ecosystems implies developing industrial systems and CBM that mitigate pollution and maintain material and energy flows within local environment, improving local wellbeing and attractiveness [107]. According to [108], Eco-industrial parks (EIP) support the systemic IE approach by optimizing energy and material exchanges from by-products and waste across various industries within the parks. IS can also be applied at the level of a whole city as projects in Guiyang (China) where improving industrial solid waste exchanges, traditional recycling, heat exchange and recovery from municipal waste, resulted in both a reduction of resources consumption and carbon footprint [109]. Conversely, smaller structures at the single facility level can also trigger the development of new CBM as well as the engagement of local communities, maintaining and regenerating natural, manufactured, financial, human, and social capitals [110].

Research on IS focuses on the manufacturing sector which generates important quantity of waste but can also intensively benefit from them [104]. In industry, imitating the ecological system, as IS suggests, contributes to carbon neutrality [111]and yields economic benefits [112]. Nonetheless, Neves et al. [104] show also that non-industrial sectors garnered the interest of researchers, those are for instance the built sector, urban ecosystem, green, circular bioeconomy and urban farming.

Circular bioeconomy is defined as an economic model that uses renewable and biological resources to produce food, materials, and energy within circular schemes. Cities, due to their proximity and diversity of resources, land types, and companies, are well-positioned to reduce costs and enhance exchanges in this domain [113]. An assessment of urban bioeconomic potential shows that cities offer a promising context for resource extraction from waste and biomass, environmental stewardship, and the development of new technologies and BM [114]. In this model, waste repurposed from one activity to another follows IS principles. Examples include using coffee silverskin from roasting processes in bakery products [112]or recycling EEEW using microbial processes that reduce chemical use and carbon emissions [115]. Other approaches draw directly from nature’s regenerative principles, advocating for green infrastructure (GI) that enhances biodiversity and local ecosystems, mitigates climate change impacts, brings nutrients and resources, and improves overall urban environmental quality[116].

Urban agriculture.

Another contribution to the sustainable and circular transition of cities is the development of UA. As Opitz et al. [117] note, even in the Global North, food security has become a critical issue, particularly in urban areas that often lack access to high-quality food. This concern can be addressed through UA, which can help meet household-level food needs but still requires stronger promotion and integration throughout *peri*-urban areas. The role of UA in enhancing food security appears to be more significant in wealthier countries than in developing ones, particularly in supporting access to nutritious food for less affluent citizens [118].

A study of its role in promotion the CE in two Nordic cities reveals that UA helps to reduce resources consumption [119]. In another paper, Skar et al. [120] review the various UA applications (e.g. aquaponics, indoor, vertical or rooftop farming, community gardens,…) and conclude that UA applications plays a crucial role in creating more sustainable cities by integrating various resource streams and improving food consumption patterns. Finally, in addition to its contribution to new BM and climate change adaptation, UA also can empower marginalized groups and promote social inclusion when developed through social and solidarity economy [121,120].

Hydroponic agriculture and vertical farming are two UA applications that have garnered significant attention in the literature. Hydroponics consists of soilless cultivation, where plants grow using a controlled mixture of water and nutrient solutions. Experiments with hydroponic systems in urban areas show that they can align with CE principles, contributing to enhanced local resilience, food security, and water and resource efficiency [122]. Another study, while emphasizing the need for further research, suggests that hydroponic UA could utilize wastewater for cultivation, thereby increasing the economic value of low-value materials and reinforcing urban CE value creation[123]. Vertical farming, on the other hand, involves the use of controlled indoor environments with vertically stacked growing systems. For Martin et al. [124], given the substantial quantity of waste generated in cities, vertical farms systems present numerous opportunities to exploit them, resulting in important reduction of GHG emissions due to positive synergies and reduced logistic. However, in some cases, it may lead to increased material and water depletion. Finally, another strand of literature explores the implementation of UA in various urban spaces such as rooftops, emphasizing the potential for GHG emission reductions and improved household resource efficiency [125,126].

Green infrastructure and nature-based solutions.

GI and NBS are key components in the literature on UCE, fully enshrined in the development of new applications and ecosystems aiming to develop regenerative, circular and resilient cities. Although closely related, GI is often considered a subset of NBS [127]. Literature defines NBS as approaches inspired by nature that aim to reintroduce natural elements into urban areas, whereas GI refers to the spatial organization of interconnected urban environments to support the implementation of such NBS [128].

GI applied in water contexts is often referred to as blue-green infrastructure, or blue infrastructure. This includes systems like for instance wetlands, dry wells, green roofs, pervious pavements, retention ponds or other that play a role in stormwater management and wastewater treatment while being cost-effective and adapted to urban environment [129]. NBS such as green roofs and vertical greening systems help close water cycles by capturing rainwater and using greywater for irrigation, thereby increasing net water use efficiency [90]. Moreover, as discussed in Subsection 3.1, some NBS contribute to wastewater treatment and the purification of water for reuse. However, NBS related to wastewater management, such as irrigating crops with treated effluent, using greywater for toilet flushing and other specific activities, or producing biogas from sludge water, extend beyond simple water purification. They generate broader value by enabling the reuse of wastewater nutrients, the production of renewable energy, and the promotion of resource circularity, offering a more integrated and systemic perspective on urban water management [130,131].

Additionally, GI contributes to urban water supply by integrating storm and rainwater into broader urban water management schemes [132]. Water management through NBS further supports the development of circular cities by creating regenerative and accessible urban spaces that provide flood and drought protection, the WFE nexus, and enhance water purification. Collectively, these interventions improve water quality, regulate microclimates, promote biodiversity, enhance social well-being, and increase energy efficiency [133]. When addressing water security, Hong and Park [134] analyzed the water metabolism of South Korean water stressed city of Paju and found that water recycling strategies are more effective than rainwater harvesting for reducing water imports, but also that to absorb increasing water demand, combined strategies are more sustainable than relying primarily on the expansion of the water supply infrastructure. [135]. Decentralized water systems, including technologies like water-aware appliances, rainwater harvesting, greywater recycling, and urban drainage solutions, can enhance neighborhood resilience and reduce dependency on centralized services and must be recognized as a long-term socio-technical challenge [136,135].

Beyond water management, NBS and GI offer additional benefits. A global survey across 17 cities found that involving citizens in NBS initiatives increases their understanding and motivation to adopt sustainable behaviors, supporting the circular transition [137]. Furthermore, an assessment of potential benefits related to tree coverage increasing, another form of GI reveals both socioeconomic and environmental benefits thanks to pollutants removal, carbon sequestration, interaction with nature and stormwater management [138]. Another aspect of NBS and GI is their contribution to circular and regenerative cities (where urban stocks and flows are self-renewing) through bioconnectivity which is the set of application and infrastructure aiming to connect human and nature while supporting their co-evolving development [116]. Furthermore, the installation of GI, such as wetlands, urban forests, and other reflective surfaces, contributes to urban cooling, which, particularly in the context of global warming, enhances both urban quality of life and the resilience of energy systems [138,139,129].

Although NBS serve various purposes, their implementation is often monothematic. Greater benefits could be achieved by applying a CE framework that integrates multiple ecosystems. The European Cooperation in Science and Technology Action initiative exemplifies this holistic approach by combining five dimensions, namely the built environment, urban water, resource recovery, urban farming, and society, to promote a “resourceful” city [128]. These cities aim to be resilient and sustainable by developing self-reproducing sociocultural systems. In such cities, the role of NBS, and especially GI, is critical, as it supports the implementation of urban sub-systems that emulate natural ecosystems wherever possible [140].

Circular governance approaches and applications

Circular city as driver of sustainable development.

This axis gathers articles advocating that circular policies are a component of sustainable transition strategies. Circular cities are seen as attractive solutions to by countries constrained by financial pressures and growing uncertainties that hinder green transition [141]. In a literature review investigating how UCE contributes to SDG, Cervantes Puma et al. [142] found that applying policy and regulatory framework generates co-benefits for achieving urban carbon neutrality, aligning with the 2030 Agenda, particularly through impacts on consumption, resource efficiency, and regenerative practices. Moreover, several other studies suggest that CE applications contribute to meet SDG ambitions and growing concerns related to resources scarcity [143]and WM-related issues in developing countries [144]. Another positive aspect of CE policies identified by Stavropoulos et al. [145], is their positive association with urban competitiveness, as they increase the attractiveness of greenfield foreign direct investment (FDI) and contribute to the creation of circular jobs.

Circularity assessment and performance monitoring.

CE is often assessed and monitored by methods such as life cycle assessment (LCA) and material flow analysis (MFA). These tools help identify systems with the greatest potential for environmental improvement. They also provide a holistic understanding of the environmental impacts and benefits of circular strategies, both pre- and post-implementation, thereby supporting better practices and informed decision-making [146,147]. Moreover, researchers frequently use these tools to evaluate CE practices in sectors like construction, UA, or WM e.g.[148–150].

LCA regroups methods used to measure at the product, territorial or organizational level the environmental performance of a product, supply-chain activity, actors or others by measuring the resources necessary and their impacts across all the life-cycle stages [151]. Conversely, MFA or material and energy flows analysis (MEFA), when including energy flows, bounds the analysis within a defined space and timeframe. It assumes that inputs equal outputs (according to thermodynamic laws) and maps material evolution within a system to understand outcomes (e.g. waste, products, GHGs) and identify where new policies or strategies might improve CE performance [152,150].

However, both approaches have limitations. As Saadé et al. [147] note, LCA in built sectors is often embedded in broader project contexts which include transport, energy, and biodiversity issues which, requiring thus complementary indicators like MFA or other CE indicators for a more comprehensive picture. Papageorgiou et al. [146] also advocate that coupling MEFA with LCA might better inform decision-makers and enhance understanding of urban systems. Moreover to Ventura [151], LCA assesses environmental performance at the object level, being unable to measure the transition in its globality; therefore the author proposes that to assess the transition, what matters is to compare the different scenario to choose the better path. Furthermore, the socio-economic complexity of urban systems requires new data sets and frameworks [153].

Another important component of municipality governance is the performance assessment of CE in municipalities. Municipal performance monitoring of CE differs from LCA and MFA by focusing on governance effectiveness and outcomes rather than product or system-level impacts. These indicators are often co-created by a range of stakeholders with diverse interests, making them locally adaptable and fostering greater buy-in for implementation [154,155]. Nonetheless, Radu and Lux [156] argue that municipalities underutilize CE performance disclosures compared to the private sector, missing an opportunity to improve transparency and public awareness of circular strategies.

Circular economy implementation through urban planning.

Implementing CE at the municipal level presents new governance challenges. Although urban planning considerations in CE literature remain underexplored, particularly regarding social dimensions [157], the academic literature is not inexistent. To develop CE through policy-making, Turcu and Gillie [158] propose a shift from “governing planning” to “governance planning”; which means setting policy objectives, implement and monitor them while considering a multilevel and stakeholder-driven approach. The importance of multi-level governance is reinforced by a qualitative case study done in six European cities which identified key governance challenges including the absence of integrated legal and political frameworks, limited public awareness, and technological barriers, necessitating therefore a multi-stakeholders approach to tackle the complexity and variety of the processes entailed by the circular transition [159].

Besides multi-stakeholder approaches, spatial dimension of the UCE also gained some traction. A case study in Glasgow identified four CE-relevant urban systems: natural/ecological systems (e.g., green/blue infrastructure for bio-regeneration); built/property systems (managing land/buildings); energy/mobility systems (grey infrastructure for CE utility services); and socio-productive systems (businesses and actors affecting consumption/production) [160]. Urban planning necessitates both bottom-up and top-down approaches, but also a horizontal integration of industrial, social, infrastructural and cultural systems as whole [161]. Moreover, to bring circularity within cities the concept of circular development underscores the need to align spatial governance with CE, arguing that market transformation must be accompanied by policy reform and land-use changes to support circular infrastructure, co-location of industries, and ecological regeneration[157]. It highlights the importance of devoting, in spatial and urban governance, spaces for low-value circular activities such as for instance the co-location of industries for IS, UA or and ecological regeneration, often hindered by the economic pressure of high cost of urban land as well as infrastructure fostering circular applications [162]. Therefore, the value proposed by the strategies applied here lays in their contribution to socio-technical and ecological transition aligning thus with the similarly named theory [160,161]. Indeed, understanding the socio-spatial dynamics in the CE help to integrate the diverse and multi-levels systems of urban life, making of the city an ideal place to overcome systemic lock-ins [163].

The stakes of circular and sustainability transition through UCE.

CE has gained prominence on the political agenda of many cities globally and the stakes of this transition have been widely discussed in the literature. In review of six European cities, Prendeville et al. [164] identify policy implications, long-term vision, and the role of knowledge and experimentation as critical for circular development; however, they also highlight a lack of consensus on what constitutes a circular city and a reliance on bottom-up approaches from businesses and communities despite that may lead to mismatches when CE is poorly understood. Moreover most of the research and UCE application focused on WM and wastewater management, as well as recycling and recovery strategies even though those are often considered “lower-level” strategies, meaning they are not necessarily the most efficient or value-generative [165,20].

When discussing the drivers of the transition, scholars emphasize the importance of a multi-dimensional approach that is both emancipatory and technocratic. It includes a technocratic agenda focused on optimizing urban flows, improving resource efficiency, and promoting IE; a business-oriented agenda driven by CBM and digital solutions; a holistic agenda aimed at restoring the ecological integrity of cities; and an activist agenda advocating for the democratization of urban flows [163]. For other researchers, an explanation to the focus on lower options such recycling rather than reducing lays in linear mindset and limited scope of municipal mandates, the lack of suitable technologies and high-costs of recycled materials [165].

Another point emphasized in literature on UCE transition is the importance of social dimension. Despite being necessary to make CE truly transformative, social dimension has been neglected in an important part of the literature which focused on employment and governance aspects although CE impacts on culture, health and citizens’ considerations are also necessary[20].

Integrating citizens makes of them actors and drivers of innovation, it implies for cities to develop places enabling them to invent new circular approaches and reappropriate their surrounding environment [75]. In such citizen-centered contexts, cities can become spaces for shaping new imaginaries that support transformative pathways and create both environmental and inclusive value through CE [166]. Citizens are political actors, subject to behavior change which shape circular cities through commercial or political activities but they also are subject to the condition of their environment which implies some responsibilities to municipalities and commercial actors in terms of infrastructure, WM schemes, or solutions provided [167].

Scholars and practical implications

In line with the literature review, several implications can be drawn for both research and practice to answer RQ3. The CE, CBM, socio-technical transitions (STT), urban studies and IE theories offer valuable frameworks for understanding the literature, identifying future research directions and developing a comprehensive understanding of what UCE applications are and how leveraging the creation of value.

Strategies prioritization and value creation in a global context (circular economy strategies)

First the applications discussed can be scrutinized according to Morsoletto’s classification of CE targets (2020). The latter presents 10 targets for CE grouped around three objectives: 1) smarter manufacturing and products use; 2) prolonging of products and components lifespan; 3) making better use of used products and materials. An important part of the applications studied in Section 5 focus on making better use of used products and materials, for instance through WM. Nonetheless, as noted by Campbell-Johnston et al. [165] and Vanhuyse et al. [20] such applications of lower-order may not necessarily be the most circular or value-generating strategies, due to the entropy associated with recycling processes, resource degradation and high costs [168,7]. As Potting et al. [8] suggest, other levels of circularity can avoid waste generation and create more value. Moreover, the question of WM in terms of urban strategic orientation needs to be carefully considered in relation to its contribution to carbon neutrality. Indeed, MSW and it treatment represent an important cause of GHG emissions that requires prioritizing circular strategies that mitigate these emissions through waste minimization and better conditions for efficient recycling [169].

Therefore, although prioritizing high-value strategies yield positive and desirable outcomes, lower strategies still have crucial stakes that urban policies cannot dismiss. Indeed, CE transition offers interesting opportunities to tackle both global issues and the required shifts in socioeconomic systems [23]. Such consideration also opens a new question on the role CE policies have regarding CE contribution to global issues and public policies that follow. In that regard, UCE strategies become not solely a local strategy but encompass more global stakes related to climate changes and global issues mitigation (water and resources scarcity, supply-chains disruption…), implying that local factors and policies have broader impacts on sustainable public policies [25,66]. They thus bring economic, social, and environmental added value to societies by playing a central role in promoting the SDG and Agenda 2030 principles and offering local solutions to global challenges [142].

Another part consists of applications related to NBS, GI and reconsiderations of the built environment that can be classified as aiming to increase the value emanating from the products or urban environment by improving their use and providing holistic value to citizens, businesses, and ecosystems. Although potentially more positive, such applications remain confined to niche sectors such as UA and suffering of small diffusion. These observations bring to light important implications for both researchers and decision-makers regarding the strategic prioritization of CE applications and the value they generate in urban contexts.

When such applications are not directed at specific BM but rather at the use of infrastructure, or digital infrastructure, the theory of the urban commons can explain how sharing infrastructure or NBS generates collective value. This is achieved by socializing neighborhoods, producing urban goods and services, and increasing both the quality of life and available space for lower-income households [170].

For researchers, the prevalence of applications focused on end-of-pipe solutions, while necessary, may not fully align with the higher-value circular strategies. This points to a gap in exploring and promoting upstream interventions, such as smarter manufacturing and strategies to extend product and infrastructure lifespans, all while fostering new urban behaviors and forms of urbanity that generate greater systemic value. Additionally, how UCE applications benefit society is also crucial for understanding how UCE will be positive for citizens. Future research should therefore integrate holistic assessment frameworks that include environmental, economic, and social value dimensions, while identifying optimal solutions among diverse pathways.

The same applies to decision-makers and business actors, for whom applying the assessment methods proposed in Subsection 5.4 could help prioritize strategies based on the full range of existing options, as outlined by Ventura [151]. These insights underline the importance for practitioners of adopting strategies that go beyond mere recycling and reuse. Instead, they should aim to preserve the value of materials, components, and infrastructure across their full life cycles. The other way to create value will also be to transmit value to citizens by enabling them to grasp the value offered by UCE applications. Such strategies apply not only to infrastructure and WM policies but also to new legislation and economic and social policies that can drive a broader paradigm shift in urban areas.

The crucial stake of urban CBM (circular-business models theories)

This critique and the need to develop new circular strategies align with a broader issue identified in the review: research often neglects CBM strategies and emerging economic practices, apart from exceptions like digital solutions and UA. Most examined applications focus on developing systems and policies to support UCE at the macro or meso scale, while specific CBMs and micro-level dynamics remain underexplored. This may be explained by another point identified in the review: a lack of practitioner knowledge about CE and a prevailing linear mindset that overlooks the systemic shift required [165,164].

However, CBM research remains crucial. As Purushothaman et al. [171] note, circular strategies transition will necessitate crucial components such as the use of new technologies (AI blockchain, and IoT), specific resource, manpower as well as financial, and government support. Moreover, as Lewandowski [172] argues, “the global shift from one model of economy to another also concerns smaller companies on a micro-level”. In such context, cities given their characteristics (proximity, resources, agent diversity…) and the availability of all the resources, technologies, knowledge as well as a critical mass for creating a supporting demand, appears ideal places to develop circular strategies, at all company-scale, and support their growth.

In the review some opportunities such as facilities or industrial parks to gathering diverse CBM [108,110]or ULL and urban innovation to generate grassroots initiatives or CBM are identified [76,74]. The opportunities offered by digitalization to create, capture, and deliver circular value is also highlighted, though it still requires CBM innovation and systemic change beyond technology [173]. At the same time, some activities, especially those not generating sufficient economic returns, face viability challenges in competitive and high-cost urban environments [162].

Consequently, in further research, deepening drivers and barriers to CBM development and value creation in urban areas considering the specificities and functions of cities appears promising and necessary. Moreover, among CBM, product service systems show potential to deliver value via circular schemes through tangible and intangible actions on either persons or things [174]. The specificities of such applications could be deepened in urban context by researchers, as some seminal studies pointed out that such applications could deliver value in housing [175]or MSW management [176]. This value creation process will also strongly rely on consumer practices that can prompt practitioners to adapt their CBM but that are weakened by current consumers habits, resulting in an objective to changes mentalities but also create more positive conditions [177]. Moreover, the CBM theory offers several underlying orientations such as, among others, resources-based views theory stressing the role of expertise, infrastructure, or relationships in leveraging a competitive advantage and the diffusion of innovation theory, that suggests that social systems, and factors like trialability, or observability affects adoption rates and behavior changes [171]that propose promising avenues for more thorough research in urban contexts.

For decision-makers, this underscores the importance of supporting ecosystems that enable CBM development by facilitating the conditions (space, incentives, infrastructure) to the experimentation and creation of new CBM tailored to urban specificities and aligned with higher-value circular strategies. Additionally, addressing micro-level practices and stimulating demand through public procurement, citizen engagement, and consumer behavior is essential to scale UCE practices, foster grassroots initiatives, enable urban innovation, advancing CBM development and fully leveraging the transformative potential of the CE and value creation process. By aligning research, innovation, and urban policy, stakeholders can participate alongside decision makers in a more inclusive, viable, and systemic approach to circularity. The urban scale, far from being a constraint, offers fertile ground for pushing circular transition when the diversity of actors and scales involved is meaningfully engaged. Achieving this will also require better understanding and knowledge among citizens and companies, an outcome that can be influenced through specific policies and educational initiatives.

Systemic lock-ins to overcome (socio-technical transition theory)

From those findings we can derive that UCE faces systemic lock-ins which can be analyzed through STT lens. This framework emphasizes that sustainable transition requires systemic changes not only technological but also societal, political, infrastructural, and BM evolutions and interactions occurring across various actors according to the multi-level perspective (MLP) [178,179]. MLP sees the transition as interactions between three levels [178]. In urban contexts, the first level, niche innovation, consists of various applications which are still at early stages of development and implementation, constrained by limited adoption, or by institutional and infrastructural inertia. The second level: socio-technical regimes, is conditioned by cities through their organization, legislation or land use and strongly influences the development of UCE applications and their potential to scale and reach a systemic level of diffusion. The third level, the socio-technical landscape (climate, demographic, resource scarcity…), intensified in cities, will play a crucial role by providing exogenous conditions that push cities toward more circular practices. Moreover, within STT framework, intermediaries are crucial since they facilitate collaboration, aligning visions, and promoting learning across levels [180]. This is particularly relevant for cities, as they host a diversity of stakeholders, including firms, institutions, and local communities, underscoring their importance in sustainable transition.

For researchers, the identification of systemic lock-ins within urban contexts and the multi-dimensional nature of UCE underlines the importance of advancing both theoretical and empirical applications of STT and MLP. Researchers are encouraged to further investigate how these interactions apply in different urban settings, considering local governance structures, socio-economic conditions, and infrastructural constraints. Integrating intermediaries and stakeholders in STT dynamics emerges as a promising research avenue to build effective roadmaps to catalyze change at the urban level.

For decision-makers, those findings highlight the need to move beyond isolated technological solutions, toward a systemic change across institutional, regulatory, and infrastructural dimensions. Urban policies should be designed to actively support niche innovation, its scaling and diffusion, while also addressing regime-level constraints that hinder systemic circular practices. Addressing this challenge involves revisiting land use policies, WM regulations, procurement strategies, and long-term infrastructural investments to create enabling conditions for circular initiatives [159,162]. It also requires the integration of intermediaries (EIP, ULL, digitalization, and public–private platforms…) and stakeholders (citizens, firms, non-governmental organization…) to facilitate this transition, particularly in complex urban environments. Finally, it remains important to align policies and institutional reforms with a reflexive governance approach that promotes experimentation, monitoring, and adaptive learning. Such approaches will help cities to refine their strategies and long-term impact of UCE initiatives.

Governance and institutional challenges (institutional and urban political ecology theories)

The sustainable transition of cities, and associated value creation, requires the integration of regime-level changes and a critical examination of governance roles through urban and political science frameworks. Institutional theory postulates that organizations shape their behavior according to regulations, social norms, structures and constraints from relevant institutions. It helps to understand why some applications might thrive better than others in cities, since these are also institutions shaping local behavior and decision-making [181,182]. A review of sustainable transition through institutional theory reveals that proactive governance, high level of institutionalization, and coercive changes contribute significantly to cities transition [183]. Additionally, linking CBM and institutional theories, Arranz and Arroyabe [181] highlight the role of consumption policies, more efficient in fostering CBM development than production policies, emphasizing the lever role of institutional policies such as regulation and information instruments. Although the literature addressed consumption dimensions by stressing the importance of knowledge, new imaginaries and citizen participation, it remains relatively underexplored. Nevertheless, it remains central to CE's transformative potential, as value creation is contingent upon meeting authentic and evolving societal demands. Further research is thus needed to examine the role of institutional drivers and barriers within cities and understanding how these dynamics shape urban transition.

The Urban Political Ecology (UPE) framework examine the interactions between various actors operating within capitalist and structuralist environment [184]. This lens offers an explanation to the prioritization of some applications and identifies some critical stakes related to UCE. Indeed, according to UPE, if UCE remains predominantly a tools for corporate and political elites, it risks becoming a technocratic fix within urban governance that fails to treat the negative aspects of economic activities without reconsidering the whole system [185]. With such perspective, the prioritization of WM, digitalization to improve efficiency, uneven land-use allocation, and lack of higher order CBM. This view also underscores the need to reinforce social components of UCE and democratize the transition and its shaping imaginaries.

For decision-makers, these findings highlight their role in shaping UCE development. Their decisions regarding infrastructure, institutional arrangements, and urban metabolism directly affect the performance and inclusivity of circular initiatives. It matters therefore to improve their understanding of UCE, identify the dynamics and build holistic frameworks for circular cities while making the transition truly democratic [40].

Developing cities as regenerative and resilience places (IE and resilience theories)

A final important theoretical perspective engages resilience and IE theories. These theories discuss respectively cities' adaptation to exogenous shocks (climate change, resources scarcity) and the development of closed energy and resources metabolisms. Resilience and self-sustaining principles impregnated urban theories under different frameworks such as circular cities or circular urbanism redesigning cities not just as consumers of resources but as dynamic agents capable of regeneration[186]. To this end, some of the applications studied by the literature reflect this perspective. For instance, WM and green ecosystem (subsections 5.1 and 5.3) include applications such as urban mining, UA, localized food waste systems and others. These initiatives contribute to enhancing urban resilience by reducing reliance on global supply chains, generating local value, and, particularly in green ecosystems, aligning with higher-order strategic objectives. This rethinking of urban metabolism also aligns strongly with IE theory which strongly influenced academic thinking on CE. Indeed, according to Saavedra [187], without the existence of IE concepts and tools, the evolution of the CE concept would not have been possible. This interlinkage explains a certain focus on material and energy exchanges and recovery to maximize symbiotic linkages within systems rather than addressing complex socio-technical dynamics and institutional transformations [188].

Although IS, WM, and data-driven applications will continue with the advancement of digital technologies [57], this emphasis on metabolic efficiency and regeneration must be coupled with social learning and participatory governance to avoid technocratic traps, and be applied through higher order strategies and a systemic reconsideration of urban functioning when possible. For researchers, this calls for further research on the implementation of regenerative and resilient applications while integrating interdisciplinary and social elements. The relationship between urban IE and CBM could also be deepened to develop new applications aligned with higher-order strategies. Similarly, practical implications would involve designing circular plans which surpass technocratic efficiency and see resilience and urban regeneration also as social and economic tools.

Conclusion and limitations

The purpose of this review is to understand what CE applications within urban environments are and what are the stakes associated in terms of value creation and implementation. To achieve this, keywords were mapped through a bibliometrics analysis to identify the main axes of research. Afterwards, the main applications were reviewed. The value creation perspective is important because it makes sense of the relevance and potential impact of UCE applications or policies. This perspective supports researchers, firms, and civil society in making informed decisions and trade-offs, providing clarity on what CE in urban areas entails.

This article shows that UCE literature is structured around four axes: 1) WM, 2) new forms of urbanity, 3) green ecosystems and 4) circular governance. Different analytical lenses such as CE classification, CBM, STT, IE, institutional theory and others are used. The main applications and the related value are summarized in Table 2. Overall, the value proposed by CE varies across the axes. Some applications still function as technocratic fixes, operating within lower-value order CE strategies. They mitigate the adverse impacts of urban activities, addressing global challenges through local applications and generating multiple forms of value. However, they do not necessarily aim to transform prevailing urban paradigms, lifestyles, or consumption practices. The reasons might be systemic lock-ins, institutional and policy orientations, or limited consumer demand.

Conversely some other applications fully aim to bring higher-value order objective into urban areas, developing new circular systems despite also suffering from the issue of being rarely scalable at city-wide level. However, in the absence of grassroots demand, even lower-value applications propose an important contribution to urban challenges and deliver a holistic and desirable value. Nonetheless, the development of new CBM and a broad-based shift in urban knowledge, behavior, and consumption patterns will be critical for driving the UCE transition forward, creating systems and applications aligned with this objective.

From the keywords and content analyses, it appears that there remains significant room for further investigation. Business and economics as well as urban studies research areas appear relatively underexplored. Studying their role in the development of urban practices to address all the CE objectives and at higher scale of implementation appears promising and necessary. Similarly, identifying the barriers and drivers of UCE, behavioral attitudes, and urban organization will support the development of urban neighborhoods that catalyze UCE development, CBM creation, and sustainable social habits.

Key recommendations for researchers and practitioners identified in the review include:

- Prioritizing high-value circular strategies: Shifting focus from end-of-pipe solutions to upstream strategies like smarter manufacturing, extending products and infrastructure lifespan, new consumption habits and product use;
- Advancing urban CBM: Promoting research on micro-level dynamics and support experimentation with CBM suited to urban contexts, particularly product-service systems, identify CBM' drivers and barriers;
- Overcoming systemic lock-ins: Apply STT frameworks to identify and address institutional, infrastructural, and behavioral barriers. Supporting niche innovations and intermediary actors to foster systemic change;
- Strengthening governance and institutions: Developing inclusive governance frameworks that integrate citizen participation, knowledge exchange, and regulatory alignment to ensure socially embedded and democratically driven UCE transitions.
- Pursuing resilience and regeneration objective: continuing to research and to implement IE and resilience into urban design to create self-sustaining systems which adapt to urban challenges while integrating new perspectives on value creation and social dimensions.

Several limitations should be acknowledged. The first relate to the methodology. Indeed, as the review applied is systematic and the search criteria fixed, it may omit some important articles or subjects if those were not referenced accordingly. Additionally, despite the application of selection criteria, article inclusion ultimately depends on the author's judgment, introducing potential bias. Another limitation lies in the theoretical lens adopted. The review focuses on value creation through UCE applications, drawing on selected theoretical frameworks. It offers thus a partial view and may overlook other relevant aspects or alternative explanations that other perspectives could provide.

Nonetheless, given the comprehensive scope of the review, which draws on a substantial body of articles, applies a systematic and reproducible methodology, and engages with widely accepted theoretical frameworks, we believe the insights are valid and useful for decision-makers, researchers, and economic and social actors. Moreover, the value creation perspective helps to concretely understand how CE is implemented in urban settings and how these insights can guide cities' transition. The task now falls to the actors of this promising field, still partially unexplored, to deepen the research, design roadmaps and policies and identify the most actionable measures for advancing the transition toward sustainable urban futures.

CRediT authorship contribution statement

Alexandre Coussa: Writing – review & editing, Validation, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

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

Acknowledgements

I would like to express my sincere gratitude to Josephine Krupa (University of Oxford) for proofreading the manuscript. My sincere thanks also go to Professor Philippe Gugler (University of Fribourg) for his invaluable guidance throughout the research process. Finally, I would like to thank the two anonymous Reviewers and the Editor for their insightful comments on the manuscript.

Appendix

A1: Table of Abbreviations

Abbreviation	Meaning
AI	Artificial intelligence
BM	Business Model
CBM	Circular Business Model
CDW	Construction and Demolition Waste
CE	Circular Economy
EEEW	Electrical and Electronic Equipment Waste
EIP	Eco-Industrial Park
EMAF	Ellen MacArthur Foundation
FDI	Foreign Direct Investment
GHG	Greenhouse Gas
GI	Green Infrastructure
IE	Industrial Ecology
ICT	Information and Communication Technology
IoT	Internet of Things
IS	Industrial Symbiosis
LCA	Life Cycle Assessment
MEFA	Material and Energy Flows Analysis
MFA	Material and Flows Analysis
MLP	Multi-Level Perspective
MSW	Municipal Solid Waste
RQ	Research Question
SDG	United Nation Sustainable Development Goals
STT	Socio-Technical Transition
UA	Urban Agriculture
UCE	Urban Circular Economy
ULL	Urban Living Labs
UPE	Urban Political Ecology
WoS	Web of Science
WTE	Waste to Energy

Data availability

No data was used for the research described in the article.

References

[1] Goyal S, Chauhan S, Mishra P. Circular economy research: a bibliometric analysis (2000–2019) and future research insights. Journal of Cleaner Production 2021;287:125011. https://doi.org/10.1016/j.jclepro.2020.125011.

[2] Merli R, Preziosi M, Acampora A. How do scholars approach the circular economy? a systematic literature review. Journal of Cleaner Production 2018;178:703–22. https://doi.org/10.1016/j.jclepro.2017.12.112.

[3] Kirchherr J, Yang N-H-N, Schulze-Spüntrup F, Heerink MJ, Hartley K. Conceptualizing the Circular Economy (Revisited): an Analysis of 221 Definitions. Resources, Conservation and Recycling 2023;194:107001. https://doi.org/10.1016/j.resconrec.2023.107001.

[4] Kirchherr J, Reike D, Hekkert M. Conceptualizing the circular economy: an analysis of 114 definitions. Resources, Conservation and Recycling 2017;127:221–32. https://doi.org/10.1016/j.resconrec.2017.09.005.

[5] Geissdoerfer M, Savaget P, Bocken NMP, Hultink EJ. The Circular Economy – a new sustainability paradigm? Journal of Cleaner Production 2017;143:757–68. https://doi.org/10.1016/j.jclepro.2016.12.048.

[6] Ellen Mac Arthur Foundation, 2025. What is a circular economy? URL https://www.ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview (accessed 2.25.25).

[7] Morseletto P. Targets for a circular economy. Resources, Conservation and Recycling 2020;153:104553. https://doi.org/10.1016/j.resconrec.2019.104553.

[8] Potting J, Hekkert M, Worrell E, Hanemaaijer A. Circular economy: measuring innovation in the product chain 2017;No. 2544. Planbureau voor de Leefomgeving.

[9] Sekulić M, Stojanović V, Pantelić M, Nađ I. Impact of the circular economy on quality of life: a systematic literature review. Geographica Pannonica 2022;26:79–92. https://doi.org/10.5937/gp26-36059.

[10] Williams J. Circular cities. Urban Studies 2019;56:2746–62. https://doi.org/10.1177/0042098018806133.

[11] Ekins, P., Domenech, T., Drummond, P., Bleischwitz, R., Hughes, N., Lotti, L., 2019. The Circular Economy: What, Why, How and Where. Presented at the Managing environmental and energy transitions for regions and cities, Paris.

[12] Shahin V, Alimohammadlou M. Current status and emerging trends on urban circular economy: a bibliometric analysis. Environ Dev Sustain 2024. https://doi.org/10.1007/s10668-024-05169-1.

[13] Lakatos ES, Yong G, Szilagyi A, Clinci DS, Georgescu L, Iticescu C, et al. Conceptualizing Core Aspects on Circular Economy in Cities. Sustainability 2021;13:7549. https://doi.org/10.3390/su13147549.

[14] Remøy H, Wandl A, Ceric D, Van Timmeren A. Facilitating Circular Economy in Urban Planning. UP 2019;4:1–4. https://doi.org/10.17645/up.v4i3.2484.

[15] Dindarian, A., 2022. Overview: The smart sustainable city initiatives and the circular economy, in: Circular Economy and Sustainability. Elsevier, pp. 369–384. DOi: 10.1016/B978-0-12-819817-9.00004-1.

[16] Murthy V, Ramakrishna S. A Review on Global E-Waste Management: Urban Mining towards a Sustainable Future and Circular Economy. Sustainability 2022;14:647. https://doi.org/10.3390/su14020647.

[17] Tsui T, Peck D, Geldermans B, Van Timmeren A. The Role of Urban Manufacturing for a Circular Economy in Cities. Sustainability 2020;13:23. https://doi.org/10.3390/su13010023.

[18] Petit-Boix A, Leipold S. Circular economy in cities: reviewing how environmental research aligns with local practices. Journal of Cleaner Production 2018;195:1270–81. https://doi.org/10.1016/j.jclepro.2018.05.281.

[19] Joensuu T, Edelman H, Saari A. Circular economy practices in the built environment. Journal of Cleaner Production 2020;276:124215. https://doi.org/10.1016/j.jclepro.2020.124215.

[20] Vanhuyse F, Fejzić E, Ddiba D, Henrysson M. The lack of social impact considerations in transitioning towards urban circular economies: a scoping review. Sustainable Cities and Society 2021;75:103394. https://doi.org/10.1016/j.scs.2021.103394.

[21] Hart SL, Milstein MB. Creating sustainable value AMP 2003;17:56–67. https://doi.org/10.5465/ame.2003.10025194.

[22] Lashitew AA, Van Tulder R, Muche L. Social Value Creation in Institutional Voids: a Business Model Perspective. Business & Society 2022;61:1992–2037. https://doi.org/10.1177/0007650320982283.

[23] Hartley K, Baldassarre B, Kirchherr J. Circular economy as crisis response: a primer. Journal of Cleaner Production 2024;434:140140. https://doi.org/10.1016/j.jclepro.2023.140140.

[24] Georgescu LP, Fortea C, Antohi VM, Balsalobre-Lorente D, Zlati ML, Barbuta-Misu N. Economic, technological and environmental drivers of the circular economy in the European Union: a panel data analysis. Environ Sci Eur 2025;37:76. https://doi.org/10.1186/s12302-025-01119-4.

[25] Georgescu LP, Barbuta Misu N, Antohi VM, Fortea C, Zlati ML. Approaches and perspectives on the transition to the circular economy in the European Union. Front Environ Sci 2025;13:1533776. https://doi.org/10.3389/fenvs.2025.1533776.

[26] Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C. D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, J.M., Hróbjartsson, A., Lalu, M.M., Li, T., Loder, E.W., Mayo-Wilson, E., McDonald, S., McGuinness, L.A., Stewart, L.A., Thomas, J., Tricco, A.C., Welch, V.A., Whiting, P., Moher, D., 2021. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ n71. DOi: 10.1136/bmj.n71.

[27] Ruiz-Real JL, Uribe-Toril J, De Pablo Valenciano J, Gázquez-Abad JC. Worldwide Research on Circular Economy and Environment: a Bibliometric Analysis. IJERPH 2018;15:2699. https://doi.org/10.3390/ijerph15122699.

[28] Van Eck N, Waltaman L. VOSviewer Manual, Leiden University. Press. ed. Netherlands: EZ Leiden; 2022.

[29] Mayes-Ramírez MM, Gálvez-Sánchez FJ, Ramos-Ridao ÁF, Molina-Moreno V. Urban Waste: Visualizing the Academic Literature through Bibliometric Analysis and Systematic Review. Sustainability 2023;15:1846. https://doi.org/10.3390/su15031846.

[30] Ghisellini P, Ncube A, Casazza M, Passaro R. Toward circular and socially just urban mining in global societies and cities: present state and future perspectives. Front Sustain Cities 2022;4:930061. https://doi.org/10.3389/frsc.2022.930061.

[31] Colangelo G, Facchini F, Ranieri L, Starace G, Vitti M. Assessment of carbon emissions' effects on the investments in conventional and innovative waste-to-energy treatments. J Clean Prod 2023;388:135849. https://doi.org/10.1016/j.jclepro.2023.135849.

[32] Haraguchi M, Siddiqi A, Narayanamurti V. Stochastic cost-benefit analysis of urban waste-to-energy systems. Journal of Cleaner Production 2019;224:751–65. https://doi.org/10.1016/j.jclepro.2019.03.099.

[33] Fogarassy C, Hoang NH, Nagy-Pércsi K. Composting Strategy instead of Waste-to-Energy in the Urban Context—A Case Study from Ho Chi Minh City. Vietnam Applied Sciences 2022;12:2218. https://doi.org/10.3390/app12042218.

[34] Lee RP, Meyer B, Huang Q, Voss R. Sustainable waste management for zero waste cities in China: potential, challenges and opportunities. Clean Energy 2020;4:169–201. https://doi.org/10.1093/ce/zkaa013.

[35] Ciuła J, Generowicz A, Gronba-Chyła A, Kwaśnicki P, Makara A, Kowalski Z, et al. Energy production from landfill gas, emissions and pollution indicators–Opportunities and barriers to implementing circular economy. Energy 2024;308:132951. https://doi.org/10.1016/j.energy.2024.132951.

[36] Szyba M, Mikulik J. Analysis of Feasibility of Producing and using Biogas in Large Cities, based on the example of Krakow and its Surrounding Municipalities. Energies 2023;16:7588. https://doi.org/10.3390/en16227588.

[37] De Souza LCG, Drumond MA. Decentralized composting as a waste management tool connect with the new global trends: a systematic review. Int J Environ Sci Technol 2022;19:12679–700. https://doi.org/10.1007/s13762-022-04504-1.

[38] Brown S, Butman D, Kurtz K. Steps to circularity: Impact of resource recovery and urban agriculture in Seattle and Tacoma. Washington Journal of Environmental Management 2023;345:118648. https://doi.org/10.1016/j.jenvman.2023.118648.

[39] Iida A, Terada T, Tsuchiya K, Yamaguchi T, Yokohari M. Rediscovering circularity in productive urban landscapes. Urban Forestry & Urban Greening 2024;96:128339. https://doi.org/10.1016/j.ufug.2024.128339.

[40] Morrow O, Davies A. Creating careful circularities: Community composting in New York City. Trans Inst British Geog 2022;47:529–46. https://doi.org/10.1111/tran.12523.

[41] Arcas-Pilz V, Gabarrell X, Orsini F, Villalba G. Literature review on the potential of urban waste for the fertilization of urban agriculture: a closer look at the metropolitan area of Barcelona. Sci Total Environ 2023;905:167193. https://doi.org/10.1016/j.scitotenv.2023.167193.

[42] Erälinna L, Szymoniuk B. Managing a Circular Food System in Sustainable Urban Farming. Experimental Research at the Turku University Campus (Finland). Sustainability 2021;13:6231. https://doi.org/10.3390/su13116231.

[43] Parsa A, Van De Wiel M, Schmutz U, Taylor I, Fried J. Balancing people, planet, and profit in urban food waste management. Sustainable Production and Consumption 2024;45:203–15. https://doi.org/10.1016/j.spc.2024.01.003.

[44] Botelho Junior AB, Martins FP, Cezarino LO, Liboni LB, Tenório JAS, Espinosa DCR. The sustainable development goals, urban mining, and the circular economy. The Extractive Industries and Society 2023;16:101367. https://doi.org/10.1016/j.exis.2023.101367.

[45] Kakkos E, Heisel F, Hebel DE, Hischier R. Towards Urban Mining—Estimating the potential Environmental Benefits by applying an Alternative Construction Practice. A Case Study from Switzerland Sustainability 2020;12:5041. https://doi.org/10.3390/su12125041.

[46] Luciano A, Altamura P, Baiani S, Cutaia L. The building stock as an urban mine: the case of the circular regeneration of disused buildings. Sustainable Chemistry and Pharmacy 2023;33:101104. https://doi.org/10.1016/j.scp.2023.101104.

[47] Oliveira JD, Schreiber D, Jahno VD. Circular economy and buildings as material banks in mitigation of environmental impacts from construction and demolition waste. Sustainability 2024;16:12. https://doi.org/10.3390/su16125022.

[48] Zandonella Callegher C, Grazieschi G, Wilczynski E, Oberegger UF, Pezzutto S. Assessment of building materials in the European residential building stock: an analysis at EU27 level. Sustainability 2023;15:11. https://doi.org/10.3390/su15118840.

[49] Scialpi G, Perrotti D. The use of urban biowaste and excavated soil in the construction sector: a literature review. Waste Manag Res 2022;40:262–73. https://doi.org/10.1177/0734242X211000430.

[50] Moradi R, Yazdi M, Haghighi A, Nedjati A. Sustainable resilient E-waste management in London: a circular economy perspective. Heliyon 2024;10:e34071. https://doi.org/10.1016/j.heliyon.2024.e34071.

[51] Shittu OS, Williams ID, Shaw PJ. Global E-waste management: can WEEE make a difference? a review of e-waste trends, legislation, contemporary issues and future challenges. Waste Management 2021;120:549–63. https://doi.org/10.1016/j.wasman.2020.10.016.

[52] Xavier LH, Giese EC, Ribeiro-Duthie AC, Lins FAF. Sustainability and the circular economy: a theoretical approach focused on e-waste urban mining. Resources Policy 2021;74:101467. https://doi.org/10.1016/j.resourpol.2019.101467.

[53] Fatimah YA, Govindan K, Sasongko NA, Hasibuan ZA. The critical success factors for sustainable resource management in circular economy: Assessment of urban mining maturity level. Journal of Cleaner Production 2024;469:143084. https://doi.org/10.1016/j.jclepro.2024.143084.

[54] Shittu OS, Williams ID, Shaw P, Montiero N, Creffield R. Demonstrating reuse of EEE in a distinct urban mine: a case study. Detritus 2021;78–93. https://doi.org/10.31025/2611-4135/2021.15091.

[55] Peiró LT, Girón AC, Durany I. Examining the feasibility of the urban mining of hard disk drives. Journal of cleaner production 2020;248. https://doi.org/10.1016/j.jclepro.2019.119216.

[56] D'Amico G, Arbolino R, Shi L, Yigitcanlar T, Ioppolo G. Digitalisation driven urban metabolism circularity: a review and analysis of circular city initiatives. Land Use Policy 2022;112:105819. https://doi.org/10.1016/j.landusepol.2021.105819.

[57] D'Amico G, Arbolino R, Shi L, Yigitcanlar T, Ioppolo G. Digital Technologies for Urban Metabolism Efficiency: Lessons from Urban Agenda Partnership on Circular Economy. Sustainability 2021;13:6043. https://doi.org/10.3390/su13116043.

[58] Anttiroiko A-V. Smart Circular Cities: Governing the Relationality, Spatiality, and Digitality in the Promotion of Circular Economy in an Urban Region. Sustainability 2023;15:12680. https://doi.org/10.3390/su151712680.

[59] Maiurova A, Kurniawan TA, Kustikova M, Bykovskaia E, Othman MHD, Singh D, et al. Promoting digital transformation in waste collection service and waste recycling in Moscow (Russia): applying a circular economy paradigm to mitigate climate change impacts on the environment. Journal of Cleaner Production 2022;354:131604. https://doi.org/10.1016/j.jclepro.2022.131604.

[60] Castiglione A, Cimmino L, Di Nardo M, Murino T. A framework for achieving a circular economy using the blockchain technology in a sustainable waste management system. Comput Ind Eng 2023;180:109263. https://doi.org/10.1016/j.cie.2023.109263.

[61] Honic M, Ferschin P, Breitfuss D, Cencic O, Gourlis G, Kovacic I, et al. Framework for the assessment of the existing building stock through BIM and GIS. Developments in the Built Environment 2023;13:100110. https://doi.org/10.1016/j.dibe.2022.100110.

[62] Lekan M, Rogers HA. Digitally enabled diverse economies: exploring socially inclusive access to the circular economy in the city. Urban Geography 2020;41:898–901. https://doi.org/10.1080/02723638.2020.1796097.

[63] Esmaeilian B, Wang B, Lewis K, Duarte F, Ratti C, Behdad S. The future of waste management in smart and sustainable cities: a review and concept paper. Waste Management 2018;81:177–95. https://doi.org/10.1016/j.wasman.2018.09.047.

[64] Franchina L, Calabrese A, Inzerilli G, Scatto E, Brutti G, Bonanni DLÁ, et al. Thinking green: the role of smart technologies in transforming cities' waste and supply Chain's flow. Cleaner Engineering and Technology 2021;2:100077. https://doi.org/10.1016/j.clet.2021.100077.

[65] Kurniawan TA, Maiurova A, Kustikova M, Bykovskaia E, Othman MHD, Goh HH. Accelerating sustainability transition in St. Petersburg (Russia) through digitalization-based circular economy in waste recycling industry: a strategy to promote carbon neutrality in era of Industry 4.0. Journal of Cleaner Production 2022;363:132452. https://doi.org/10.1016/j.jclepro.2022.132452.

[66] Li J, Li X, Liu H, Gao L, Wang W, Wang Z, et al. Climate change impacts on wastewater infrastructure: a systematic review and typological adaptation strategy. Water Research 2023;242:120282. https://doi.org/10.1016/j.watres.2023.120282.

[67] Möslinger M, Ulpiani G, Vetters N. Circular economy and waste management to empower a climate-neutral urban future. Journal of Cleaner Production 2023;421:138454. https://doi.org/10.1016/j.jclepro.2023.138454.

[68] Gherghel A, Teodosiu C, De Gisi S. A review on wastewater sludge valorisation and its challenges in the context of circular economy. Journal of Cleaner Production 2019;228:244–63. https://doi.org/10.1016/j.jclepro.2019.04.240.

[69] Kehrein P, Van Loosdrecht M, Osseweijer P, Posada J, Dewulf J. The SPPD-WRF Framework: a Novel and Holistic Methodology for Strategical Planning and Process Design of Water Resource Factories. Sustainability 2020;12:4168. https://doi.org/10.3390/su12104168.

[70] Vassalle L, Ferrer I, Passos F, Filho CRM, Garfí M. Nature-based solutions for wastewater treatment and bioenergy recovery: a comparative Life Cycle Assessment. Science of The Total Environment 2023;880:163291. https://doi.org/10.1016/j.scitotenv.2023.163291.

[71] Guerra-Rodríguez S, Oulego P, Rodríguez E, Singh DN, Rodríguez-Chueca J. Towards the Implementation of Circular Economy in the Wastewater Sector: challenges and Opportunities. Water 2020;12:1431. https://doi.org/10.3390/w12051431.

[72] Hu T-S, Pan S-C, Lin H-P. Development, Innovation, and Circular Stimulation for a Knowledge-based City: Key Thoughts. Energies 2021;14:7999. https://doi.org/10.3390/en14237999.

[73] Chen P, Chu Z, Zhao Y, Li Y. Is urban innovation capacity shaping new models of economic development? evidence from the circular economy. Sustain Dev 2025;33:758–70. https://doi.org/10.1002/sd.3134.

[74] Della Spina L. A Decision support Evaluation Framework for Community-based Collaborative Urban Regeneration Processes. Sustainability 2024;16:6434. https://doi.org/10.3390/su16156434.

[75] Diesch A, Massari M. Hidden gems: the potential of places and social innovation for circular territories in Bogotá. Cities 2024;144:104645. https://doi.org/10.1016/j.cities.2023.104645.

[76] Ai H, Islam N, Kumar Mangla S, Song M, Tan X. Circular Economy, Open Innovation, and Green Innovation: Empirical evidence from Prefecture-Level Cities in China. IEEE Trans Eng Manag 2024;71:5706–19. https://doi.org/10.1109/TEM.2024.3357350.

[77] Wu Y, Wei X, Liu Y, Li H. Can the Circular Economy Demonstration Policy Enhance the Green Innovation Level? A Quasi-Natural Experiment from China Sustainability 2024;16:3480. https://doi.org/10.3390/su16083480.

[78] Fuso Nerini F, Slob A, Ericsdotter Engström R, Trutnevyte E. A Research and Innovation Agenda for Zero-Emission European Cities. Sustainability 2019;11:1692. https://doi.org/10.3390/su11061692.

[79] Cuomo F, Ravazzi S, Savini F, Bertolini L. Transformative Urban living Labs: Towards a Circular Economy in Amsterdam and Turin. Sustainability 2020;12:7651. https://doi.org/10.3390/su12187651.

[80] Florez Ayala DH, Alberton A, Ersoy A. Urban living Labs: Pathways of Sustainability Transitions towards innovative City Systems from a Circular Economy Perspective. Sustainability 2022;14:9831. https://doi.org/10.3390/su14169831.

[81] Hannon J, Zaman A, Rittl G, Rossi R, Meireles S, Palandi FED. Moving Toward Zero Waste Cities: a Nexus for International Zero Waste Academic Collaboration (NIZAC). In: Leal Filho W, Bardi U, editors. Sustainability on University Campuses: Learning, Skills Building and Best Practices, World Sustainability Series. Cham: Springer International Publishing; 2019. p. 379–414. https://doi.org/10.1007/978-3-030-15864-4_24.

[82] Särkilahti M, Åkerman M, Jokinen A, Rintala J. Temporal challenges of building a circular city district through living-lab experiments. European Planning Studies 2022;30:1333–54. https://doi.org/10.1080/09654313.2021.1965963.

[83] Greer R, Von Wirth T, Loorbach D. The diffusion of circular services: Transforming the dutch catering sector. Journal of Cleaner Production 2020;267:121906. https://doi.org/10.1016/j.jclepro.2020.121906.

[84] Kumdokrub T, Carson S, You F. Cornell university campus metabolism and circular economy using a living laboratory approach to study major resource and material flows. Journal of Cleaner Production 2023;421:138469. https://doi.org/10.1016/j.jclepro.2023.138469.

[85] Bucci Ancapi F, Van Den Berghe K, Van Bueren E. The circular built environment toolbox: a systematic literature review of policy instruments. J Clean Prod 2022;373:133918. https://doi.org/10.1016/j.jclepro.2022.133918.

[86] Arora M, Raspall F, Cheah L, Silva A. Buildings and the circular economy: estimating urban mining, recovery and reuse potential of building components. Resour Conserv Recycl 2020;154:104581. https://doi.org/10.1016/j.resconrec.2019.104581.

[87] Arora M, Raspall F, Cheah L, Silva A. Residential building material stocks and component-level circularity: the case of Singapore. J Clean Prod 2019;216:239–48. https://doi.org/10.1016/j.jclepro.2019.01.199.

[88] Isoaho K, Valkama P. Understanding circular city policies as a discontinuation strategy: Policy insights from circular construction. Environmental Innovation and Societal Transitions 2024;52:100897. https://doi.org/10.1016/j.eist.2024.100897.

[89] Megyesi B, Gholipour A, Cuomo F, Canga E, Tsatsou A, Zihlmann V, et al. Perceptions of stakeholders on nature-based solutions in urban planning: a thematic analysis in six European cities. Urban Forestry & Urban Greening 2024;96:128344. https://doi.org/10.1016/j.ufug.2024.128344.

[90] Pearlmutter D, Pucher B, Calheiros CSC, Hoffmann KA, Aicher A, Pinho P, et al. Closing Water Cycles in the built Environment through Nature-based Solutions: the Contribution of Vertical Greening Systems and Green Roofs. Water 2021;13:2165. https://doi.org/10.3390/w13162165.

[91] Foster G. Circular economy strategies for adaptive reuse of cultural heritage buildings to reduce environmental impacts. Resources, Conservation and Recycling 2020;152:104507. https://doi.org/10.1016/j.resconrec.2019.104507.

[92] Pintossi N, Ikiz Kaya D, Pereira Roders A. Assessing Cultural Heritage Adaptive Reuse Practices: Multi-Scale challenges and Solutions in Rijeka. Sustainability 2021;13:3603. https://doi.org/10.3390/su13073603.

[93] Poli G, Muccio E, Cerreta M. Circular, Cultural and Creative City Index: a Comparison of Indicators-based Methods with a Machine-Learning Approach. Aestimum 2023;81. https://doi.org/10.36253/aestim-13880.

[94] Foster G, Saleh R. The Adaptive Reuse of Cultural Heritage in European Circular City Plans: a Systematic Review. Sustainability 2021;13:2889. https://doi.org/10.3390/su13052889.

[95] Santibanez Gonzalez EDR, Kandpal V, Machado M, Martens ML, Majumdar S. A Bibliometric Analysis of Circular Economies through Sustainable Smart Cities. Sustainability 2023;15:15892. https://doi.org/10.3390/su152215892.

[96] Vardopoulos I, Papoui-Evangelou M, Nosova B, Salvati L. Smart 'Tourist Cities' Revisited: Culture-led Urban Sustainability and the Global Real Estate Market. Sustainability 2023;15:4313. https://doi.org/10.3390/su15054313.

[97] Damianou A, Vayona A, Demetriou G, Katos V. An actionable maturity planning model for smart, circular cities. Cities 2023;140:104403. https://doi.org/10.1016/j.cities.2023.104403.

[98] Lewandowska A, Rogatka K, Lopata E. Social Awareness of the Circular Economy as an Integral Part of Sustainable Development. Observations from Poland. Civil and Environmental Engineering Reports 2022;32:132–53. https://doi.org/10.2478/ceer-2022-0023.

[99] Dincă G, Milan A-A, Andronic ML, Pasztori A-M, Dincă D. Does Circular Economy Contribute to Smart Cities' Sustainable Development? IJERPH 2022;19:7627. https://doi.org/10.3390/ijerph19137627.

[100] Koop SHA, Van Leeuwen CJ. The challenges of water, waste and climate change in cities. Environ Dev Sustain 2017;19:385–418. https://doi.org/10.1007/s10668-016-9760-4.

[101] Taddeo R. Bringing the local back in. the role of territories in the "biological" transition process toward circular economy: a perspective of analysis. Front Sustain 2022;3:967938. https://doi.org/10.3389/frsus.2022.967938.

[102] Huang C, Yang J, Lu H, Huang H, Yu L. Green Spaces as an Indicator of Urban Health: evaluating its changes in 28 Mega-Cities. Remote Sensing 2017;9:1266. https://doi.org/10.3390/rs9121266.

[103] Richards DR, Thompson BS. Urban ecosystems: a new frontier for payments for ecosystem services. People and Nature 2019;1:249–61. https://doi.org/10.1002/pan3.20.

[104] Neves A, Godina R, Azevedo SG, Matias JCO. A comprehensive review of industrial symbiosis. Journal of Cleaner Production 2020;247:119113. https://doi.org/10.1016/j.jclepro.2019.119113.

[105] Al-Thani NA, Al-Ansari T. Comparing the convergence and divergence within industrial ecology, circular economy, and the energy-water-food nexus based on resource management objectives. Sustainable Prod Consumption 2021;27:1743–61. https://doi.org/10.1016/j.spc.2021.04.008.

[106] Fan YV, Varbanov PS, Klemeš JJ, Romanenko SV. Urban and industrial symbiosis for circular economy: Total EcoSite Integration. Journal of Environmental Management 2021;279:111829. https://doi.org/10.1016/j.jenvman.2020.111829.

[107] Gamidullaeva L, Shmeleva N, Tolstykh T, Shmatko A. An Assessment Approach to Circular Business Models within an Industrial Ecosystem for Sustainable Territorial Development. Sustainability 2022;14:704. https://doi.org/10.3390/su14020704.

[108] Belaud J-P, Adoue C, Vialle C, Chorro A, Sablayrolles C. A circular economy and industrial ecology toolbox for developing an eco-industrial park: perspectives from French policy. Clean Techn Environ Policy 2019;21:967–85. https://doi.org/10.1007/s10098-019-01677-1.

[109] Fang K, Dong L, Ren J, Zhang Q, Han L, Fu H. Carbon footprints of urban transition: Tracking circular economy promotions in Guiyang, China. Ecological Modelling 2017;365:30–44. https://doi.org/10.1016/j.ecolmodel.2017.09.024.

[110] Mulrow JS, Derrible S, Ashton WS, Chopra SS. Industrial Symbiosis at the Facility Scale. J of Industrial Ecology 2017;21:559–71. https://doi.org/10.1111/jiec.12592.

[111] Huan J, Han L. Potential Contribution to Carbon Neutrality Strategy from Industrial Symbiosis: evidence from a Local Coal-Aluminum-Electricity-Steel Industrial System. Sustainability 2022;14:2487. https://doi.org/10.3390/su14052487.

[112] Ansanelli G, Fiorentino G, Chifari R, Meisterl K, Leccisi E, Zucaro A. Sustainability Assessment of Coffee Silverskin Waste Management in the Metropolitan City of Naples (Italy): a Life Cycle Perspective. Sustainability 2023;15:16281. https://doi.org/10.3390/su152316281.

[113] Sobol A. Urban Bioeconomy in Poland: Experience and potential. GNPJE 2022;311:84–92. https://doi.org/10.33119/GN/151796.

[114] Taylor Buck N, While A. The urban bioeconomy: extracting value from the ecological and biophysical. Journal of Environmental Planning and Management 2021;64:182–201. https://doi.org/10.1080/09640568.2020.1763931.

[115] Ilyas S, Srivastava RR, Kim H, Das S, Singh VK. Circular bioeconomy and environmental benignness through microbial recycling of e-waste: a case study on copper and gold restoration. Waste Management 2021;121:175–85. https://doi.org/10.1016/j.wasman.2020.12.013.

[116] Sala Benites H, Osmond P. Bioconnections as Enablers of Regenerative Circularity for the built Environment. UP 2021;6:25–39. https://doi.org/10.17645/up.v6i4.4373.

[117] Opitz I, Berges R, Piorr A, Krikser T. Contributing to food security in urban areas: differences between urban agriculture and peri-urban agriculture in the Global North. Agric Hum Values 2016;33:341–58. https://doi.org/10.1007/s10460-015-9610-2.

[118] Badami MG, Ramankutty N. Urban agriculture and food security: a critique based on an assessment of urban land constraints. Glob Food Sec 2015;4:8–15. https://doi.org/10.1016/j.gfs.2014.10.003.

[119] De Jesus A, Aguiar Borges L. Pathways for Cleaner, Greener, Healthier Cities: what is the Role of Urban Agriculture in the Circular Economy of two Nordic Cities? Sustainability 2024;16:1258. https://doi.org/10.3390/su16031258.

[120] Skar SLG, Pineda-Martos R, Timpe A, Pölling B, Bohn K, Külvik M, et al. Urban agriculture as a keystone contribution towards securing sustainable and healthy development for cities in the future. Blue-Green Systems 2020;2:1–27. https://doi.org/10.2166/bgs.2019.931.

[121] Lee S. Role of social and solidarity economy in localizing the sustainable development goals. International Journal of Sustainable Development & World Ecology 2020;27:65–71. https://doi.org/10.1080/13504509.2019.1670274.

[122] Rufí-Salís M, Petit-Boix A, Villalba G, Sanjuan-Delmás D, Parada F, Ercilla-Montserrat M, et al. Recirculating water and nutrients in urban agriculture: an opportunity towards environmental sustainability and water use efficiency? Journal of Cleaner Production 2020;261:121213. https://doi.org/10.1016/j.jclepro.2020.121213.

[123] Reynolds LP, Leme VFC, Davidson PC. Investigating the Impacts of Wastewaters on Lettuce (Lactuca sativa) seed Germination and growth. Agriculture 2024;14:608. https://doi.org/10.3390/agriculture14040608.

[124] Martin M, Weidner T, Gullström C. Estimating the potential of Building Integration and Regional Synergies to Improve the Environmental Performance of Urban Vertical Farming. Front Sustain Food Syst 2022;6:849304. https://doi.org/10.3389/fsufs.2022.849304.

[125] Piezer K, Petit-Boix A, Sanjuan-Delmás D, Briese E, Celik I, Rieradevall J, et al. Ecological network analysis of growing tomatoes in an urban rooftop greenhouse. Science of The Total Environment 2019;651:1495–504. https://doi.org/10.1016/j.scitotenv.2018.09.293.

[126] Toboso-Chavero S, Montealegre AL, García-Pérez S, Sierra-Pérez J, Muñoz-Liesa J, Gabarrell Durany X, et al. The potential of local food, energy, and water production systems on urban rooftops considering consumption patterns and urban morphology. Sustainable Cities and Society 2023;95:104599. https://doi.org/10.1016/j.scs.2023.104599.

[127] Carvalho PN, Finger DC, Masi F, Cipolletta G, Oral HV, Tóth A, et al. Nature-based solutions addressing the water-energy-food nexus: Review of theoretical concepts and urban case studies. J Clean Prod 2022;338:130652. https://doi.org/10.1016/j.jclepro.2022.130652.

[128] Langergraber G, Pucher B, Simperler L, Kisser J, Katsou E, Buehler D, et al. Implementing nature-based solutions for creating a resourceful circular city. Blue-Green Systems 2020;2:173–85. https://doi.org/10.2166/bgs.2020.933.

[129] Stefanakis A. The Role of Constructed Wetlands as Green Infrastructure for Sustainable Urban Water Management. Sustainability 2019;11:6981. https://doi.org/10.3390/su11246981.

[130] Kisser J, Wirth M, De Gusseme B, Van Eekert M, Zeeman G, Schoenborn A, et al. A review of nature-based solutions for resource recovery in cities. Blue-Green Systems 2020;2:138–72. https://doi.org/10.2166/bgs.2020.930.

[131] Oral HV, Carvalho P, Gajewska M, Ursino N, Masi F, Hullebusch EDV, et al. A review of nature-based solutions for urban water management in European circular cities: a critical assessment based on case studies and literature. Blue-Green Systems 2020;2:112–36. https://doi.org/10.2166/bgs.2020.932.

[132] Novaes C, Marques R. Are Rainwater and Stormwater Part of the Urban CE Efficiency? Sustainability 2023;15:11168. https://doi.org/10.3390/su151411168.

[133] Oral HV, Carvalho P, Gajewska M, Ursino N, Masi F, Hullebusch EDV, Zimmermann M. A review of nature-based solutions for urban water management in European circular cities: a critical assessment based on case studies and literature. 2020b Blue-Green Systems 2020;2(1). https://doi.org/10.2166/bgs.2020.932.

[134] Hong Y, Park J. Exploring circular water options for a water-stressed city: water metabolism analysis for Paju City. South Korea Sustainable Cities and Society 2023;89:104355. https://doi.org/10.1016/j.scs.2022.104355.

[135] Ramírez-Agudelo NA, De Pablo J, Roca E. Exploring alternative practices in urban water management through the lens of circular economy–a case study in the Barcelona metropolitan area. Journal of Cleaner Production 2021;329:129565. https://doi.org/10.1016/j.jclepro.2021.129565.

[136] Bouziotas D, Van Duuren D, Van Alphen H-J, Frijns J, Nikolopoulos D, Makropoulos C. Towards Circular Water Neighborhoods: Simulation-based Decision support for Integrated Decentralized Urban Water Systems. Water 2019;11:1227. https://doi.org/10.3390/w11061227.

[137] Cárdenas ML, Wilde V, Hagen-Zanker A, Seifert-Dähnn I, Hutchins MG, Loiselle S. The Circular Benefits of Participation in Nature-based Solutions. Sustainability 2021;13:4344. https://doi.org/10.3390/su13084344.

[138] Oliveira M, Santagata R, Kaiser S, Liu Y, Vassillo C, Ghisellini P, et al. Socioeconomic and Environmental Benefits of Expanding Urban Green areas: a Joint Application of i-tree and LCA Approaches. Land 2022;11:2106. https://doi.org/10.3390/land11122106.

[139] Pearlmutter D, Theochari D, Nehls T, Pinho P, Piro P, Korolova A, et al. Enhancing the circular economy with nature-based solutions in the built urban environment: green building materials, systems and sites. Blue-Green Systems 2020;2:46–72. https://doi.org/10.2166/bgs.2019.928.

[140] Katsou E, Nika C-E, Buehler D, Marić B, Megyesi B, Mino E, et al. Transformation tools enabling the implementation of nature-based solutions for creating a resourceful circular city. Blue-Green Systems 2020;2:188–213. https://doi.org/10.2166/bgs.2020.929.

[141] Herrador M. A Universal Circular Cities Declaration to Achieve Global Sustainability. Resources, Conservation and Recycling 2024;209:107757. https://doi.org/10.1016/j.resconrec.2024.107757.

[142] Cervantes Puma GC, Salles A, Bragança L. Nexus between Urban Circular Economies and Sustainable Development Goals: a Systematic Literature Review. Sustainability 2024;16:2500. https://doi.org/10.3390/su16062500.

[143] Dushyantha N, Kuruppu GN, Nanayakkara CJ, Ratnayake AS. The Role of Permanent Magnets, Lighting Phosphors, and Nickel-Metal Hydride (NiMH) Batteries as a Future source of Rare Earth elements (REEs): Urban Mining through Circular Economy. Min Metall Explor 2024;41:321–34. https://doi.org/10.1007/s42461-023-00904-0.

[144] Kadhila T, De Wit MP, Schenck R. A conceptual framework for sustainable waste management in small municipalities: the cases of Langebaan, South Africa and Swakopmund, Namibia. Environ Sci Pollut Res 2023;30:125088–103. https://doi.org/10.1007/s11356-023-26904-7.

[145] Stavropoulos S, Burger MJ, Dufourmont J. Urban Circular policies and Employment through Greenfield FDI. Sustainability 2020;12:1458. https://doi.org/10.3390/su12041458.

[146] Papageorgiou A, Björklund A, Sinha R, De Almeida MLR, Steubing B. Coupling material and energy flow analysis with life cycle assessment to support circular strategies at the urban level. Int J Life Cycle Assess 2024;29:1209–28. https://doi.org/10.1007/s11367-024-02320-y.

[147] Saadé M, Erradhouani B, Pawlak S, Appendino F, Peuportier B, Roux C. Combining circular and LCA indicators for the early design of urban projects. Int J Life Cycle Assess 2022;27:1–19. https://doi.org/10.1007/s11367-021-02007-8.

[148] Lederer J, Gassner A, Kleemann F, Fellner J. Potentials for a circular economy of mineral construction materials and demolition waste in urban areas: a case study from Vienna. Resources, Conservation and Recycling 2020;161:104942. https://doi.org/10.1016/j.resconrec.2020.104942.

[149] Rufí-Salís M, Calvo MJ, Petit-Boix A, Villalba G, Gabarrell X. Exploring nutrient recovery from hydroponics in urban agriculture: an environmental assessment. Resources, Conservation and Recycling 2020;155:104683. https://doi.org/10.1016/j.resconrec.2020.104683.

[150] Zeller V, Towa E, Degrez M, Achten WMJ. Urban waste flows and their potential for a circular economy model at city-region level. Waste Management 2019;83:83–94. https://doi.org/10.1016/j.wasman.2018.10.034.

[151] Ventura A. Transition life cycle assessment: a new method to face ecological transition. Front Sustain 2022;3:801668. https://doi.org/10.3389/frsus.2022.801668.

[152] Domenech T, Borrion A. Embedding Circular Economy Principles into Urban Regeneration and Waste Management: Framework and Metrics. Sustainability 2022;14:1293. https://doi.org/10.3390/su14031293.

[153] Elliot T, Vigier M, Levasseur A. Spatio-temporal metabolic rifts in urban construction material circularity. Resources, Conservation and Recycling 2024;205:107567. https://doi.org/10.1016/j.resconrec.2024.107567.

[154] Bekier J, Parisi C. Co-creating sustainability performance accounts in cities via tinkering and bricolage. JPBAFM 2025;37:156–74. https://doi.org/10.1108/JPBAFM-03-2023-0052.

[155] Bekier J, Parisi C. Co-construction of performance indicators for a circular city and its relation to a local action net. AAAJ 2023. https://doi.org/10.1108/AAAJ-07-2022-5911.

[156] Radu C, Lux G. Circular economy promotion and disclosure among Canadian municipalities. SAMPJ 2024. https://doi.org/10.1108/SAMPJ-06-2023-0445.

[157] Williams J. Circular cities: planning for circular development in European cities. European Planning Studies 2023;31:14–35. https://doi.org/10.1080/09654313.2022.2060707.

[158] Turcu C, Gillie H. Governing the Circular Economy in the City: Local Planning Practice in London. Planning Practice & Research 2020;35:62–85. https://doi.org/10.1080/02697459.2019.1703335.

[159] Obersteg A, Arlati A, Acke A, Berruti G, Czapiewski K, Dąbrowski M, et al. Urban Regions Shifting to Circular Economy: Understanding challenges for New Ways of Governance. UP 2019;4:19–31. https://doi.org/10.17645/up.v4i3.2158.

[160] Soto C, Thomson CS, Uti Nchor J. Realizing the potential for circularity in Glasgow through the socio-spatial dimension of urban systems. Building Research & Information 2024;52:957–83. https://doi.org/10.1080/09613218.2024.2375334.

[161] Van Der Leer J, Van Timmeren A, Wandl A. Social-Ecological-Technical systems in urban planning for a circular economy: an opportunity for horizontal integration. Architectural Science Review 2018;61:298–304. https://doi.org/10.1080/00038628.2018.1505598.

[162] Williams J. The role of spatial planning in transitioning to circular urban development. Urban Geography 2020;41:915–9. https://doi.org/10.1080/02723638.2020.1796042.

[163] Marin J, De Meulder B. Interpreting Circularity. Circular City Representations Concealing transition Drivers. Sustainability 2018;10:1310. https://doi.org/10.3390/su10051310.

[164] Prendeville S, Cherim E, Bocken N. Circular Cities: Mapping six Cities in transition. Environmental Innovation and Societal Transitions 2018;26:171–94. https://doi.org/10.1016/j.eist.2017.03.002.

[165] Campbell-Johnston K, Cate JT, Elfering-Petrovic M, Gupta J. City level circular transitions: Barriers and limits in Amsterdam, Utrecht and the Hague. J Clean Prod 2019;235:1232–9. https://doi.org/10.1016/j.jclepro.2019.06.106.

[166] Fratini CF, Georg S, Jørgensen MS. Exploring circular economy imaginaries in European cities: a research agenda for the governance of urban sustainability transitions. Journal of Cleaner Production 2019;228:974–89. https://doi.org/10.1016/j.jclepro.2019.04.193.

[167] Ortega Alvarado IA, Pettersen IN. The role given to citizens in shaping a circular city. Urban Geography 2024;45:611–30. https://doi.org/10.1080/02723638.2023.2221097.

[168] Korhonen J, Honkasalo A, Seppälä J. Circular Economy: the Concept and its Limitations. Ecological Economics 2018;143:37–46. https://doi.org/10.1016/j.ecolecon.2017.06.041.

[169] Oo PZ, Prapaspongsa T, Strezov V, Huda N, Oshita K, Takaoka M, et al. The role of global waste management and circular economy towards carbon neutrality. Sustainable Production and Consumption 2024;52:498–510. https://doi.org/10.1016/j.spc.2024.11.021.

[170] Feinberg A, Ghorbani A, Herder P. Diversity and challenges of the Urban Commons: a Comprehensive Review. Int J Commons 2021;15:1. https://doi.org/10.5334/ijc.1033.

[171] Purushothaman R, Alamelu R, Selvabaskar S, Sudha M. Theories, techniques and strategies of sustainable circular economy: a systematic literature review. Discov Sustain 2025;6:297. https://doi.org/10.1007/s43621-025-01161-5.

[172] Lewandowski M. Designing the Business Models for Circular Economy—Towards the Conceptual Framework. Sustainability 2016;8:43. https://doi.org/10.3390/su8010043.

[173] Parida V, Sjödin D, Reim W. Reviewing Literature on Digitalization, Business Model Innovation, and Sustainable Industry: Past Achievements and Future promises. Sustainability 2019;11:391. https://doi.org/10.3390/su11020391.

[174] Peronard J-P, Ballantyne AG. Broadening the understanding of the role of consumer services in the circular economy: Toward a conceptualization of value creation processes. Journal of Cleaner Production 2019;239:118010. https://doi.org/10.1016/j.jclepro.2019.118010.

[175] Ghafoor S, Hosseini MR, Kocaturk T, Weiss M, Barnett M. The product-service system approach for housing in a circular economy: an integrative literature review. Journal of Cleaner Production 2023;403:136845. https://doi.org/10.1016/j.jclepro.2023.136845.

[176] Casazza M, Huisingh D, Ulgiati S, Severino V, Liu G, Lega M. Product Service System-based Municipal Solid Waste circular management platform in Campania Region (Italy): a preliminary analysis. Procedia CIRP 2019;83:224–9. https://doi.org/10.1016/j.procir.2019.03.085.

[177] Hunger T, Arnold M, Ulber M. Circular value chain blind spot – a scoping review of the 9R framework in consumption. Journal of Cleaner Production 2024;440:140853. https://doi.org/10.1016/j.jclepro.2024.140853.

[178] Geels FW. Socio-technical transitions to sustainability: a review of criticisms and elaborations of the Multi-Level Perspective. Current Opinion in Environmental Sustainability 2019;39:187–201. https://doi.org/10.1016/j.cosust.2019.06.009.

[179] Geels, F.W., 2018. Socio-Technical Transitions to Sustainability, in: Oxford Research Encyclopedia of Environmental Science. Oxford University Press. DOi: 10.1093/acrefore/9780199389414.013.587.

[180] Kivimaa P, Boon W, Hyysalo S, Klerkx L. Towards a typology of intermediaries in sustainability transitions: a systematic review and a research agenda. Research Policy 2019;48:1062–75. https://doi.org/10.1016/j.respol.2018.10.006.

[181] Arranz CFA, Arroyabe MF. Institutional theory and circular economy business models: the case of the European Union and the role of consumption policies. J Environ Manage 2023;340:117906. https://doi.org/10.1016/j.jenvman.2023.117906.

[182] Lowndes V. Rescuing Aunt Sally: taking Institutional Theory Seriously in Urban Politics. Urban Studies 2001;38:1953–71. https://doi.org/10.1080/00420980120080871.

[183] Guarnieri P, Bianchini A, Rossi J, Silva CE, L., Trojan, F., Lizot, M., De Oliveira Vieira, B.. Transitioning towards a circular economy under a multicriteria and the new institutional theory perspective: a comparison between Italy and Brazil. Journal of Cleaner Production 2023;409:137094. https://doi.org/10.1016/j.jclepro.2023.137094.

[184] Swyngedouw E, Heynen NC. Urban Political Ecology, Justice and the politics of Scale. Antipode 2003;35:898–918. https://doi.org/10.1111/j.1467-8330.2003.00364.x.

[185] Kębłowski W, Lambert D, Bassens D. Circular economy and the city: an urban political economy agenda. Culture and Organization 2020;26:142–58. https://doi.org/10.1080/14759551.2020.1718148.

[186] Pekdemir S, Guaralda M, Limb M. The Missing link: Circularity in Urban Design - a Systematic Review of Circular Paradigms for Resilient and Self-sustaining Cities. Cities 2025;162:106007. https://doi.org/10.1016/j.cities.2025.106007.

[187] Saavedra YMB, Iritani DR, Pavan ALR, Ometto AR. Theoretical contribution of industrial ecology to circular economy. Journal of Cleaner Production 2018;170:1514–22. https://doi.org/10.1016/j.jclepro.2017.09.260.

[188] Bruel A, Kronenberg J, Troussier N, Guillaume B. Linking Industrial Ecology and Ecological Economics: a Theoretical and empirical Foundation for the Circular Economy. J of Industrial Ecology 2019;23:12–21. https://doi.org/10.1111/jiec.12745.