Which circularity for Urban Design and Planning? A compass to navigate Circular Economy research knowledge and methods.

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Abstract

The circular economy (CE) has taken hold among urban development plans and programmes, yet research on the application of the concept in urban design and planning is still in its infancy. This paper provides a systematic review of the literature related to CE, urban planning, and design. It investigates how the literature is clustered by subject area as well as the epistemological positioning and methodological approach of different research clusters. Results suggest that objectivist and conceptual approaches are most widespread, although practical and constructivist approaches are emerging. Planners and designers are being called upon to lead more integrative research.

Keywords

Circular Economy; Circularity, Urban Planning; Urban Design; Urban Agenda

1. Introduction: CE research and urban planning and design

With the promise of decoupling growth from resource consumption while creating jobs in times of crisis, the concept of Circular Economy (CE) is now high on the business and political agendas. The concept has gained traction among governments and institutions (China and the European Union), inter-governmental bodies (OECD), influential forums, think tanks (World Economic Forum, the Ellen MacArthur Foundation, Circle Economy), and leading corporations (Philips, Caterpillar, Renault, Veolia). More recently, in Europe it has also taken been taken up by city administrations and urban programs (Amsterdam, Brussels, Paris, etc.). Yet, despite the increasing prominence of the concept in the urban field, research on what a "circular city" could look like is still in its infancy (Hobson, 2016; Marin & Meulder, 2018; Pomponi & Moncaster, 2017; Prendeville, Cherim, & Bocken, 2018). The realisation of the CE goes hand in hand with other sustainability objectives, such as adopting cleaner production technologies, developing programs and policies for increasing producers' and consumers' responsibility and awareness, creating platforms for sharing services and products, and the increased use of renewable technologies and materials. Criticisms emphasise that CE research is mostly skewed towards technological and market solutions (Bulkeley, 2005; Gregson, Crang, Fuller, & Holmes, 2015; Murray, Skene, & Haynes, 2017), paying little attention to the governance settings or the local specificities that trigger (or hinder) greater recirculation of resources, nor the socio-spatial implications of different modes of circularity (Fratini, Georg, & Jørgensen, 2019; Heurkens & Dąbrowski, 2020; Hobson, 2020a, 2020b; Tapia, Bianchi, Pallaske, & Bassi, 2021).

The literature on the relation between the "circular economy" and "urban planning and design" is becoming more multifaceted; there is a greater variety of expertise among authors contributing to

the debate, ranging from engineering to the social sciences, providing complementary (and sometimes conflicting) insights and standpoints. Likewise, many terms are used to designate circularity-inspired ambitions by and in cities: “circular city” (Williams, 2019, 2021a), “circularisation of urban/territorial metabolism” (Amenta, Russo, & van Timmeren, 2022; Bahers, Durand, & Beraud, 2017; Giezen & Roemers, 2014; Bortolotti, Grulois, & Kampelmann, 2020; Tapia et al., 2021), “urban circularity” (Marin, 2019; Marin & Meulder, 2018; Verga & Khan, 2022), “circular urbanisms” (Grisot, 2021), etc. This article aims to bring some order to the debate through a bibliographic and qualitative content analysis of the literature. Its main research questions are: #1 Which disciplinary perspectives have most engaged with the concepts of CE relevant for urban analysis, planning, and design? #2 Which schools of knowledge and methods can urban planning scholars and practitioners leverage to implement circularity and how, in turn, can they contribute to the debate?

For this purpose, the article presents the results of a systematic literature review (using bibliometric data from Scopus) and a qualitative and critical analysis that encompasses a relatively large sample of publications. It also makes use of other complementary research tools (Elicit and Research Rabbit). Various literature reviews have been conducted on the CE over the last few years, which focus on the definitions, genealogies, and conceptual shortcomings of this concept (Ghisellini, Cialani, & Ulgiati, 2016; Homrich, Galvão, Abadia, & Carvalho, 2018; Kirchherr, Reike, & Hekkert, 2017; Murray et al., 2017; Skene, 2018) or the translation of its objectives into planning documents and policies (Fratini et al., 2019; Kennedy, Pincetl, & Bunje, 2011; Petit-Boix & Leipold, 2018; Prendeville et al., 2018; Williams, 2021a). However, none have focused on the systematic meta-analysis of the “how” of CE research at the urban scale. In

a nutshell, this article explores from what standpoints and with what methods different forms of research can contribute to the debate on circularity in urban planning and design.

The article takes a definition of urban planning that goes beyond its focus on land use and transformation to address urban resource management for urban improvement at all scales of engagement, within the public and private sectors (Agudelo-Vera, Mels, Keesman, & Rijnaarts, 2011). It also understands urban planning as the discipline at the “interface”, an inter-discipline that connects technical and social knowledge (Barles, 2018). The process of design(ing), at the core of the planning discipline, involves relating general principles to site and program requirements, which are always context and time dependent (Carmona & Tiesdell, 2007). However, the challenge of reducing the general to the specific necessitates that basic assumptions are free of determinist simplifications. In this context, the designer must simultaneously be able to integrate a certain measure of complexity and translate this complexity into the design without sacrificing breadth for depth.

Therefore, this work aims to provide a compass for academics and practitioners to navigate the multifaceted research landscape on the CE at the urban scale and to take a position with respect to the basic assumptions and methods of studying, analysing, and realising “circularity”. The following section presents the methods and tools used for the review of the literature on "circular economy” and “urban design and planning" and the qualitative content analysis. Section 3 presents the results of the bibliometric and qualitative analysis, and illustrates the main contributions of the findings to the debate on the different disciplinary perspectives. Finally, Section 4 proposes an epistemological and methodological positioning of the identified clusters and lays the foundation for a research agenda for the CE that takes advantage of the highly interdisciplinary nature of urban planning and design.

2. Methods

A three-fold approach was used to explore the depth and breadth of the researches contributing to the debate on CE in urban design and planning. Firstly, a systematic analysis of Scopus-indexed publications was completed in July 2022. For this purpose, a bibliographic database was retrieved from Scopus and used in combination with the open-licence software VOSviewer, which enables the analysis of the scientific landscape. Secondly, two other online research tools (Elicit and Research Rabbit) were tested to expand the results and identify additional relevant works on the topic. Results of these searches were combined and skimmed by looking at relevant content for urban analysis, planning, and design. The works retrieved from different databases were compiled into a table and classified by research cluster according to their disciplinary approach. Finally, a qualitative (critical) analysis of the research clusters was conducted using a 2x2 matrix as a framework that distinguished between different epistemological perspectives ("objectivist" vs. "constructivist") and different methodological approaches ("hands-on" vs. "conceptual").

2.1 The construction of the first literature dataset and the bibliometric analysis

A literature dataset was built in Scopus using the following research string: “TITLE-ABS-KEY (circular economy AND urban OR landscape OR spatial AND design OR planning AND governance OR co-production OR transition* OR materialit* OR metabolism OR logistics)”. The choice of keywords was agreed upon by the authors based on the observation of the most recurring keywords in the literature already available to the authors at the beginning of the study. The fourth set of keywords (“governance”, “co-production”, “transition”, “materiality”, “metabolism”, and “logistics”) was chosen to guide the search toward results deemed significant for research. A total of 191 document results were obtained through this query. The search was

further refined by excluding certain subject areas ("biochemistry", "physics", "chemistry", "medicine", and "mathematics"), and limiting the selection to articles, books, and book chapters written in English, French, and Italian. A final dataset consisting of 134 articles was thus obtained.

Once this dataset was obtained, the open software VOSviewer was used to map the authorship of the cited literature. More specifically, a co-citation analysis of authors based on fractional counting was carried out to highlight the most cited scholars and their connections and position within the wider research landscape. A co-citation link is a link between two items that are both cited by the same document. A minimum threshold of 10 citations per author was set, which resulted in 162 authors. The citations attribute was used to weigh the number of citations received by an author. Finally, the size variation was set to 0.7 to facilitate the visual understanding of differences in weights between authors.

2.2 The expansion of the dataset and the qualitative analysis

To verify the completeness of the Scoups dataset and the results of the bibliometric analysis, a search with alternative search tools was carried out in July 2022. Artificial intelligence-based programs were used to expand the dataset and include works from underrepresented research fields that could nonetheless be considered relevant. Two online programs were used for this purpose: Elicit – an online automated tool that finds and summarizes articles based on research questions, and Research Rabbit – a citation-based literature mapping tool that visualizes networks of communities of scholars. Initially, the following question was entered into the Elicit question bar: "How can the circular economy be realized in urban planning and design?". In addition, we indicated that the keyword "circular" should be present in all article abstracts. This search resulted in 87 articles.

This list was downloaded in *csv* format and transferred into the online software Research Rabbit. Based on Semantic Scholar, Research Rabbit provides commands that allow for the visualization of a network of connected works based on citations, similar references, or similar keywords. The relevance of a work in the network is highlighted through the number of connections it has to other works and size of the symbol representing the work. The program displayed the original 87 articles together with an additional 114 "similar" works. It also pointed out works on the original list that had no connection with each other and were therefore excluded from the selection (Angrisano & Girard, 2019; Marchesi, Tweed, & Gerber, 2020; Muñoz & Navia, 2021).

A final dataset of 374 articles, which combined the findings of Scoups, Elicit and Research Rabbit and excluded overlaps, thus composed the final database. The subsequent analysis of this database was conducted in a qualitative/critical manner, as Elicit and Research Rabbit do not allow the export of complete datasets with bibliographic references needed to run VOSviewer bibliographic analysis. The titles of the 374 articles were scanned by the authors and, finally, 74 were deemed most relevant and selected. The authors read the abstract, methodology and conclusions of each article in this sample. A table summarizing the bibliographic data and core content of each article was created. Based on this information, a column was added for the disciplinary classification of research clusters, which expands the classification proposed by Scopus.

3. Results: the clusters of CE research

3.1 Network visualization and research clustering

This section presents the results of the bibliometric analysis. Figure 1 shows the network visualisation of the co-citation analysis, which illustrates the relationship between articles,

highlighting commonalities and connections between fields of research. The co-citation analysis highlights both the authors from the original Scoups dataset and those that are cited together within this dataset (162 in total). The map identifies 5 main clusters/communities, distinguished by colour and connections between authors.

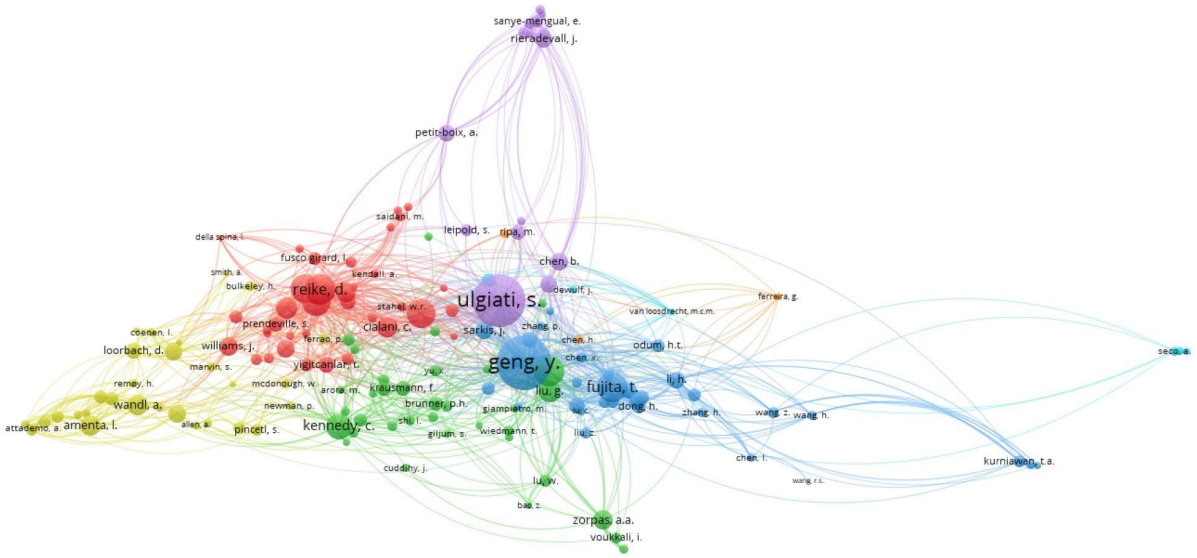

Figure 1. Network map of the co-citation analysis of cited authors based on bibliographic data (Source: Scopus; realization: VOSviewer - Copyright © 2020 Centre for Science and Technology Studies, Leiden University). Elaborated by A. Bortolotti and G. C. Verga, 2022.

Centre to the right, the blue cluster gathers authors belonging to the *Chinese School of Industrial Ecology*, who have been engaged for more than a decade in studying eco-industrial parks and cities in China, focusing in particular on industrial symbiosis and environmental assessments. The most cited author in this cluster, Geng, has widely written about industrial symbiosis, ecology, and the circular economy (Geng, Fu, Sarkis, & Xue, 2012; Geng, Sarkis, & Bleischwitz, 2019; Geng, Sarkis, Ulgiati, & Zhang, 2013; Geng, Zhu, Doberstein, & Fujita, 2009; Su, Heshmati, Geng, & Yu, 2013; Zhu, Geng, & Lai, 2010). This cluster connects with the seminal work on *System Ecology* and *Emergy Analysis* by Odum, which indeed appears in the network.

Close by on top, the purple cluster highlights scholars in *Environmental Science and Technology* from the *Parthenope University of Naples*, Italy, represented by Ripa and Ulgiati, co-authors of the often-cited literature review on the CE (Ghisellini et al., 2016). In their work, these authors couple economic and environmental analyses (*Emergy* and *Life Cycle Analysis* - LCA) at the level of the economic sector rather than at the urban and territorial level. Examples include research on construction and demolition waste (Ghisellini, Ripa, & Ulgiati, 2018), renewable energies (Corcelli, Fiorentino, Petit-Boix, Rieradevall, & Gabarrell, 2019), and waste management (Caprile & Ripa, 2014). Petit Boix and Leipold (2018) are connected to this strand of research, although, in the network map, they appear displaced on the top of the graph, as their work calls for more quantitative research into the environmental impacts of policy-driven CE initiatives at the urban scale.

Still at the centre, but slightly shifted left, the red cluster gathers scholars in *Environmental Economics* and *Urban Planning*. This cluster emphasises authors such as Reike and colleagues from the *Copernicus Institute of Sustainable Development of the Utrecht University*, the Netherlands, whose work is geared towards improving coherence around the understanding and use of the concept of CE and the multiple Rs (Reduce, Reuse, Recycle, etc.) associated with the concept (Bocken, de Pauw, Bakker, & van der Grinten, 2016; Kirchherr et al., 2017; Reike, Vermeulen, & Witjes, 2018). This cluster also includes authors in the field of urban planning such as Prendeville, Cherim & Bocken (2018), Williams (2019, 2021a, 2021b) from the United Kingdom and Fusco-Girard and Nocca (2019) from Italy. These authors provide contextual insights about the implementation of the concept in practice by reviewing its application in regional and city-planning documents across European cities (Prendeville et al., 2018) and the impacts, benefits and challenges of circular initiatives at the neighbourhood and city-scales

(Fusco Girard & Nocca, 2019; Williams, 2021b). This group also includes the Swiss architect Stahel, whose theory of the performance economy (2016, 1981) is often cited among the foundations of the CE.

Downwards, the green cluster gathers scholars in *Urban Metabolism*. Intrinsically interdisciplinary, this cluster includes authors from many different backgrounds, including authors from the *Viennese Institute of Social Ecology* (Haas, Krausmann, Wiedenhofer, & Heinz, 2015; Haberl, Wackernagel, Krausmann, Erb, & Monfreda, 2004; Haberl et al., 2019; Krausmann et al., 2009; Mayer et al., 2019) and engineers working with tools such as Material and Energy Flow Analysis (MEFA) to assess the biophysical throughputs of cities and the economy (Brunner & Rechberger, 2004; Hendriks et al., 2000; Kennedy et al., 2011).

Finally, in the left end, the yellow cluster groups scholars in *Transition Studies and Urban and Landscape Design*. These authors include Loorbach and Coenen ('Urban Sustainability Transitions', 2017) affiliated to the *Dutch Research Institute for Transitions* (DRIFT) and Marvin and Bulkeley (Hodson & Marvin, 2010) from the United Kingdom, who championed the studies of urban socio-technical systems and transition governance. Although not dealing explicitly with the CE, these authors shed light on the institutional and social embeddedness of industrial ecology and urban sustainability trajectories, building on co-evolutionary, complex system theories (Rotmans & Loorbach, 2009).Within the literature on CE, this approach is posed to fill the lack of understanding of the social dimensions that are crucial for the legitimacy and the adoption of the various modes of circularity (Fratini et al., 2019; Hobson, 2020b; Merli, Preziosi, & Acampora, 2018; Spangenberg, 2017; Vanhuyse, Fejzić, Ddiba, & Henrysson, 2021). Architects and urbanists also appear in this cluster, many of whom were affiliated with the Horizon 2020 "REPAiR" research project (2016-2020). Led by the *Delft University of*

207 *Technology*, the project made use of GIS-based mapping and co-creation processes (i.e., living
208 labs with experts and stakeholders) to enrich the CE debate (Amenta et al., 2022; Amenta & Van
209 Timmeren, 2018; Remøy, Wandl, Ceric, & Van Timmeren, 2019; Wandl et al., 2019).
210 Highlighting the absence of spatial analysis in most studies and analytical tools of urban
211 metabolism, these authors advocate its development to support spatial planning and design
212 explorations (Arciniegas & Janssen, 2012; Arciniegas et al., 2019).

213 ***3.2 Expanding research clusters through content analysis***

214 While the results of the bibliometric analysis show clear clusters of similar research topics, they
215 may fail to capture the breadth of the research on the topic. Combining searches using different
216 online tools as presented Section 2.2, we obtained a list of 374 publications relevant to our
217 search. Table 1 presents an expansion of the disciplinary classification of research clusters based
218 on the authors' expert judgment of a final selection of 74 articles. It gathers clusters identified by
219 VOSviewer (*Industrial Ecology*, *Environmental Science and Technology*, *Environmental*
220 *Economics*, *Urban Planning, Urban Metabolism*, *Transition Studies* and *Urban and Landscape*
221 *Design*) together with those suggested by the content analysis of the most cited articles among
222 those selected.

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Clusters/ disciplinary perspective	**References** (3 most cited)	**Content and Method(s)**
Industrial Ecology in China	Sun et al. (2017)	Develops and tests an integrated Material Flows Analysis (MFA) and Emergy evaluation model to investigate the environmental and ecological benefits of urban industrial

		symbiosis implementation in a typical industrial city in China.
	Wang et al. (2018)	An empirical analysis of 40 cities in China delivers an "evaluation index system for urban CE development (UCDI)" that uses entropy methodology combining expert and entropy weighting.
	Dong et al., (2016)	Presents the design and Life Cycle Analysis (LCA) of an integrated industrial and urban symbiosis for Guiyang city based on the coal, electricity, aluminium, phosphor chemical, iron/steel industry and urban symbiosis network, with linkages made between various industries through energy exchanges and process synergies.
Env Science and Tech	Ghisellini, Cialani & Ulgiati (2016)	An extensive review of the literature from the last two decades highlights the main CE features and perspectives, including its origins, basic principles, advantages and disadvantages, as well as various techniques for modelling and implementing CE at the different levels (micro, meso and macro).
	Petit-Boix & Leipold (2018)	A review of policy documents that stresses the need to quantify the environmental impact of policy-driven CE initiatives. It reviews and classifies CE initiatives reported in world cities, which largely relate to urban infrastructure and business practices.
	Ghisellini & Ulgiati (2020)	This chapter frames the CE transition as a socio-technical challenge. It highlights the substantial societal and economic changes needed to achieve more sustainable models of production and consumption.
Env Economics	Kirchherr, Reike & Hekkert (2017)	An analysis of 114 definitions of CE indicates that the concept is mostly represented as a combination of reduction, reuse and recycling activities, while the search for systemic change is sidelined. The article explains that CE is rarely explicitly linked to sustainable development and focuses mainly on economic prosperity, followed by environmental quality, with little or no attention to social equity.
Urban Planning	Prendeville, Cherim & Bocken (2018)	An empirical study of CE strategies across 6 European cities based on document review, interviews with stakeholders, and qualitative analysis (based on expanded EMF's ReSOLVE framework). It proposes a definition of the circular city as "a city that practices CE principles to close resource loops, in partnership with the city's stakeholders (citizens, community, business and knowledge stakeholders), to realize its vision of a future-proof city."
	Gravagnuolo, Angrisano, & Fusco	A review of CE actions in 8 historic European port cities highlights the lack of indicators to… and proposes a framework for "closed" urban metabolism based on LCA.

	Girard (2019) Williams (2021b) [EL]	An inductive and deductive content analysis of relevant literature and findings from interviews with stakeholders implementing circular strategies in four European cities. It proposes three actions – resource looping, adaptation, and ecological regeneration – to deliver circular development and proposes a framework of benefits that are likely to accrue from adopting this approach. It also highlights problems around the valuation of those benefits and their unequal distribution.
Urban Metabolism	Kennedy et al. (2011)	A literature review on urban metabolism studies identifies four applications in urban planning: as indicators of urban sustainability; as inputs for calculating greenhouse gas emissions in cities; as mathematical models of urban metabolism for policy analysis; and as a basis for sustainable urban design. The paper calls for greater integration of social, health and economic indicators into the urban metabolism framework.
Transition Studies	Fratini et al. (2019) [EL]	This research includes an in-depth literature review, the critical reflection on the socio-technical imaginaries underpinning CE translation in three European cities, and the development of a research agenda to support future studies and reflect on how CE might provide opportunities for socially inclusive and environmentally desirable urban transitions.
Urban and Landscape Design	Marin & Meulder (2018)	Through its application in a case-study, this article proposes an analytical framework for sorting four existing circular designs based on the authors' interpretations of the concept and "carrying worldviews". It concludes with an agenda for multi-perspective and multi-dimensional circular city design, anchored in place-specific and multi-scalar transitions.
	Amenta et al. (2019)	A case-study and comparative analysis between Urban Living Labs experiences aimed at the cocreation of site-specific eco-innovative solutions (EIS) in Naples and Amsterdam.
	Remøy et al. (2019)	An editorial article that discusses the different aspects needed to (better) integrate CE strategies in urban planning. The article concludes that resource-efficient built environments should be developed and implemented systemically and on a large, regional scale. Local authorities, citizens, and other stakeholders need a collaborative and science-informed decision environment to….
Human geography	Hobson & Lynch (2016) [RR]	A critical examination of the European Commission and Ellen Mac Arthur's framing of CE and the sharing economy that calls for greater consideration of the social and political facets of the CE, diverse economies, and degrowth.
	Savini (2019) [EL]	

	Kębłowski, Lambert, & Bassens (2020) [EL]	A critical study on the roots and legacy of CE in environmental policymaking in the Netherlands and Amsterdam framed as a "regime of eco-accumulation". A critical examination of CE policies in Brussels that promote techno-fixes biased toward technology-driven industrial change, while bracketing broader socio-political interests.
Architecture and civil engineering	Pomponi & Moncaster, (2017) [RR]	A framework to formulate building research within a CE perspective that highlights the relevance of the building mese-scale. It includes six dimensions and distinguishes between bottom-up / top-down approaches.
	Joensuu, Edelman, & Saar (2020)	A review of the literature on CE in the built environment that aims to support planning processes. It highlights the need for inclusive and location-sensitive politics functioning from bottom-up and top-down perspectives, developing positive political practices that leave room for inventions, building capacity through cross-institutional knowledge transfer, and developing communication platforms to enable knowledge-sharing, better-informed decisions, and better skills for all the stakeholders.
	Kanters (2020) [EL]	A series of semi-structured interviews with architects and consultants engaged in circular building design identifies the barriers and divers of the transformation towards a circular building sector. The article engages with key actors in the design process, namely architects and consultants.
Product (industrial) design	Bocken et al. (2016) [EL]	A literature review that discusses the product design and business model strategies to move to a CE. Building on Stahel's service economy and McDonough and Braungart cradle-to-cradle, it identifies slowing, closing, and narrowing resource loops as key strategic actions in relation to resource flows.
	van Dam et al. (2020) [RR]	A review of the literature published in industrial design journals and thematic analysis of the contribution of industrial design research to CE. It identifies four thematic areas of potential contribution: 1) design for circular production processes, 2) design for circular consumption, 3) design to support policy towards the CE, and 4) design education for the CE.
	Nogueira, Ashton, Teixeira, Lyon, & Pereira (2020) [EL]	A participatory action research project that uses industrial ecology and design methods to support decision-making processes in the reconfiguration of both hard and soft (social) infrastructure for greater material resource cycling in urban food production.

Table 1. Clustering by disciplinary perspective: examples of the most cited articles and study design (Source: Scopus, Elicit [EL] and Research Rabbit [RR]). By the authors, 2022.

This operation led to the identification of three additional disciplinary research clusters dealing with the topic, namely: *Human Geography*, *Architecture and Civil Engineering*, and *Product Design*. This second round of review highlights the fact that works in the field of design and the social sciences often go unnoticed on platforms like Scopus. This may be due to the lower representation of their publications in scientific journals and the lower number of citations. Nevertheless, these works are relevant in that they bring different perspectives and methods that illuminate aspects overlooked by other research clusters.

For instance, research on the "Circular City" in the field of *Human Geography* is conducted by Hobson (2016) and Savini (2019). These authors open the debate to other-than-capitalist political economic ontologies. They do this by shifting the focus from international *grand designs* of policies and programs to everyday practices and (re)generative spaces (Acuto, 2014), bringing back the centrality of users, citizens, and households in waste production and consumption (Hobson, 2016; Savini, 2019), rendering visible social and environmental conditions of production within the CE (Gregson et al., 2015), and rethinking socio-material engagements of individuals and communities with resources that sustain their daily life. Ultimately, these authors show a pathway for de-centering the growth paradigm and criticize top-down and pro-growth CE discourses, which are mostly focused on industry (and technological) innovations and business oriented.

Research in the field of *Architecture and Civil Engineering* focuses on reversible constructions (i.e., adaptive reuse, design-for-disassembly, design-for-repair, etc.) and the embodied energy of buildings (i.e., the energy content used in material extraction, production, and installation, etc.). Authors in the field state that the focus on the building scale fills the gap in current CE research dichotomized between a macro (the city) and micro (products) perspective (Pomponi &

Moncaster, 2017). This strand of research looks at the interconnected sphere of material standards, the construction industry, client expectations, and norms within which the architect can play the role of connector and promoter of innovative designs and products. However, circularity ambition in the construction sector is often undermined by i) a conservative industry and lack of flexibility in building regulations with respect to re-use of materials, ii) the mismatch between demand for and supply of re-use materials, iii) a lack of specific skills necessary for re-use material processing, and iv) the higher cost of reuse than for new materials (Kanters, 2020). These conclusions point to the need for an inclusive and place-sensitive policy that integrates bottom-up and top-down initiatives, addresses issues of specialised training, and develops communication platforms (i.e., material banks (Marin, Alaerts, & Van Acker, 2020)) to enable material and knowledge sharing and more informed decisions among all stakeholders (Galle et al., 2019; Salvo, Carraro, Bianchini, & Maffei, 2021; van Dam et al., 2020).

Finally, works in the *Product Design* cluster do not contribute directly to the circular city subject but, in terms of methods and research agenda, they investigate part of the broader domain of industrial ecology and sustainability (Bocken et al., 2016; van Dam et al., 2020). They provide conceptual aid for designers, innovators, and decision-makers, without questioning the very foundation of the concept. Rather, they develop strategies to incorporate the 3 or more R's principles into product design, manufacturing, and consumption patterns taking place in cities. Bocken and colleagues (2016), for instance, come up with a framework that integrates circular long-term visions with detailed business models and design strategies, geared towards slowing, closing, and narrowing resource loops either taken separately or combined, as summarized in Table 1. Beyond the elaboration of circular strategies, the design discipline is credited with contributing to the expansion of theoretical considerations on the CE, by engaging inter- and

trans-disciplinary research that links design to contributions in other fields (van Dam et al., 2020). User-centred design and applied ethnography can also contribute to the much-needed tuning of CE principles to individual and community practices, beliefs, and perceptions (Norman, 2013; Wuyts, 2022). The following section proposes a framework to position each disciplinary endeavour according to its main epistemological perspective and methodological approach.

4. Discussion

4.1. Epistemological positions and methodological approaches

The literature review reveals that the urban dimension of CE is researched from various disciplinary perspectives, including *Industrial Ecology*, *Environmental Sciences and Technology*, *Environmental Economics*, *Urban Metabolism*, *Transition Studies*, *Human Geography*, *Urban and Landscape Design*, *Architecture and Civil Engineering*, and *Product (Industrial) Design*. CE in these fields is perceived differently according to the individual theoretical roots and methodological traditions. To understand the specific position in the scientific landscape of each disciplinary cluster, a 2X2 matrix analytical framework is proposed, which distinguishes between opposing epistemological positions ("objectivist" vs. "constructivist") and methodological (working) approaches ("hands-on" vs. "conceptual"). The objectivist/constructivist dichotomy is borrowed by philosopher and planner Philippe Vandernbroeck's framework for urban metabolism spatial practices, which has already been used to discuss sustainability framings by Marin & De Meulder (2018). According to Vandernbroeck, the objectivist worldview focuses on performance and efficiency, and it intervenes in space "from the outside", considering people as objects of control, human resources, or rational utility maximisers. Knowledge is built through measurable collection and analysis of data that enables

the construction of theories. The constructivist worldview, on the other hand, focuses on potential acting from within the intervention space with situational materials. Knowledge is produced by interpretative, phenomenological research. The hands-on/conceptual dichotomy is proposed to distinguish between theoretical efforts of conceptualisation and applicative efforts of putting circularity into practice.

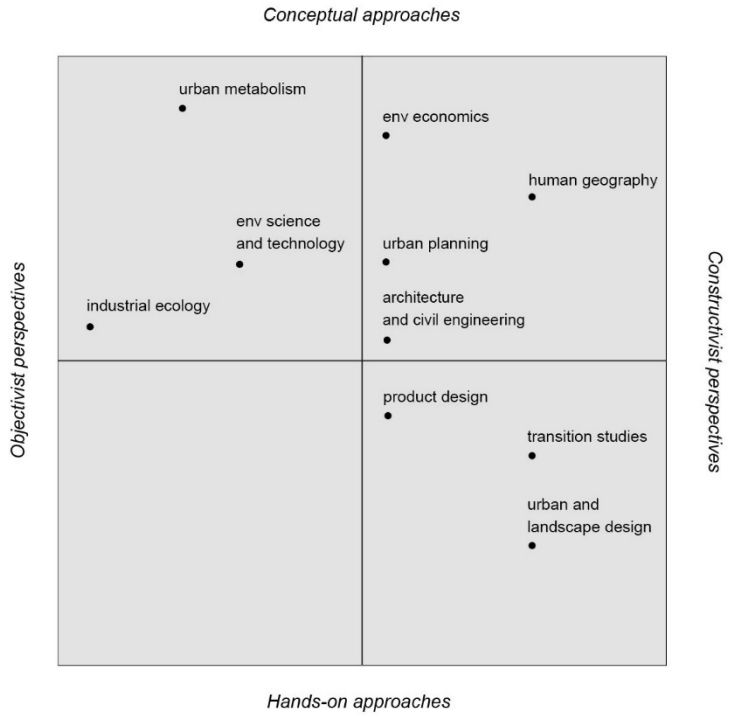

Figure 2. framework for CE research. Elaborated by A. Bortolotti and G. C. Verga, 2022.

Figure 2 shows that CE research is mostly skewed towards conceptual approaches. *Industrial Ecology*, *Urban Metabolism* and *Environmental Sciences and Technology* occupy the top-left quadrant of objectivist-conceptual endeavours. These research clusters contribute with complex quantitative analyses and urban and economic system conceptualizations based on modelling and accounting tools (i.e., Emergy, LCA, MFA etc.). *Environmental Economics*, *Human Geography*, and *Urban Planning* find their place in the top-right constructivist-conceptual quadrant. Authors in these fields contribute with situated and critical perspectives, albeit at different levels. The work

of urban planners and civil engineers, for instance, reflects on the importance of integrated, bottom-up and top-down approaches and broader stakeholder participation in steering circular practices, yet mobilizing institutionalized forms of governance and participation. On the other hand, geographers offer conceptually more radical readings of "circularity", built on in-depth contextual analyses that reveal alternative political-economic ontologies. Nevertheless, they often proposed a purely analytical instance with few practical implications. Finally, *Transition Studies*, *Urban and Landscape Design* and *Product Design* occupy the constructivist-hands-on quadrant. Works in these clusters share the use of participatory and action research methods such as urban living labs. By involving end users of products and services, these disciplines help to actively engage academics in transdisciplinary activities that integrate knowledge from different disciplines and the direct experience of users, communities, and citizens.

The results of the bibliographic analysis (Figure 1) show that publications in the fields of *Industrial Ecology* (blue cluster) and *Environmental Science and Technology* (purple cluster) count by far the most citations, indicating the objectivism is the most popular paradigm (?) in existing research. However, it is worth noting that recent contributions to the debate from areas such as *Human Geography*, *Transition Studies*, *Urban Planning, Urban and Landscape Design, Construction and Product Design* open up the research to constructivism; authors in the field of *Urban Planning* have the highest number of publications in journals (red group). Nevertheless, there is a dearth of interpretive and phenomenological research, particularly with bottom-up approaches that both test and can inform practice.

From this picture emerges the need to push future research towards bottom-up approaches that both theorise from practice and test theory. Scholars and practitioners from the applied sciences, such as planners and designers, are called upon to lead the way in offering insights of this kind.

As integrative disciplines that connect and integrate knowledge from the natural and social sciences to provide solutions to urban challenges, *Urban Planning and Design* can help bring greater consideration of the context and the final users to better translate CE research to practical applications. Scholars in CE research now call for greater co-production of knowledge and interdisciplinary research to provide more robust recommendations for sustainability transitions (Barles, 2016; Fratini et al., 2019). Within this framework, there is ample room for planners and designers to contribute with inter- and trans-disciplinary research balancing perspectives and interests on the CE with a focus on the context and final users and beneficiaries, including those who are potentially excluded.

4.2 Towards an integrative agenda

Integrating perspectives and interests requires a broad general knowledge of the wealth of research on the subject. Different approaches to the concept of CE imply different epistemologies, or worldviews, that directly affect the search for solutions. The abstract accounting of resource flows, for instance, assumes that circularity is measurable and urban and economic actors are controllable. On the other hand, in-depth qualitative analyses offer more critical readings of the social and spatial impacts of different modes of circularity, but lack the capacity to provide measurable and generalisable theories, which are useful for policy and decision-making. From what has been discussed so far, we recognise three main conceptualizations on which planners and designers can elaborate their design proposals, which are presented in Table 2:

Circularity as a closed-loop *optimization process* of resource and waste management within the urban system.	**Circularity as a concept for *rethinking the relationship between the city and its hinterland* (or operational landscapes).**	**Circularity as a *holistic concept to radically rebalance human-nature relations.***
It states that urban (sub)systems can be re-designed to become regenerative through new business models and industrial/technological development. It implies that it would be possible to reach a stage where all outputs become inputs and therefore no additional inputs are needed (i.e., EMAF, 2013). It is in contradiction with the thermodynamics and entropy law.	Fostering regionalist and territorial perspectives, it promotes synergies between city and hinterland (operational landscapes supplying goods and products) through strategies such as the pooling of resources, the reduction of distances between places of residence and work as well between place of production and consumption (Barles, 2018; Brenner, 1999; Brenner & Katsikis, 2020). It clashes with administrative issues and political-economic barriers.	It deploys a whole-systems approach aimed at rethinking and redesigning economic and social relations to radically rebalance human-nature relations, working with situational materials and resources (Boehnert, 2015). It attempts to overhaul the epistemic biases of modern though, facing limits of incommunicability and impracticability in the short term.
The *resources efficiency* paradigm.	The *recircularization of urban/territorial/regional metabolism* paradigm.	The *relational/ecological* paradigm.

Table 2. The three main interpretations of circularity for a circular urbanism. By the authors, 2022.

While the *resources efficiency* paradigm pushes one to think in terms of abstract measurements, accounting, and modelling, the other two paradigms have a stronger grip on context. The *recirculation of territorial metabolism* paradigm still reflects on urban flows and resources but considers their geographical redistribution and (political) relations between areas of production and consumption as well. Finally, a holistic and relational approach, associated to the *relational/ecological* paradigm, seems to emerge between the lines of contemporary critical thinking. This interpretation ties in more with post-structuralist, critical, ecological, and feminist works, such as those by Haraway (2016), Puig de la Bellacasa (2017) and Tsing (2020). Authors

in these areas advocate for i) an intersectional environmentalist eco-feminism take on CE practices and the inclusion of forgotten CE actors (Wuyts & Marin, 2022), (ii) the need to move beyond the city-nature (culture-nature) division and the utilitarian interpretation of "nature" (Verga & Khan, 2022), and (iii) the promotion of circularity ambitions within the principle of ecosystems' health (or 'One Health') (Wuyts, Marin, Brusselaers, & Vrancken, 2020). In this regard, emphasis is placed on the need to defend living soils and to reinterpret ecosystems as complex interactions in between humans and other/more-than-humans (including flora, fauna, mushrooms, minerals, and beyond).

5. Conclusions

This paper set out to examine the intellectual traditions that have recently grappled with the concept of CE, which show some relevance for Urban Planning and Design. It also predicts the potential contribution of Urban Planning and Design to the CE debate, while highlighting that literature in this domain is largely skewed towards conceptual-based endeavours. We contribute to the debate by emphasising the scientific and research aspects of the concept of CE and supporting further research. Limitations to this research are due to the deliberate choice of the keywords used in Scopus, and the formulation of the research question used in Elicit. We encountered some difficulties in grasping the parameters that were used by online artificial-intelligence-run platforms (Research Rabbit and Elicit), therefore, we question the scientific reliability of their data. Nevertheless, the bibliographic data gathered from Scopus constituted the base for this systematic literature review, which was only afterwards integrated with Research Rabbit and Elicit inputs. Future research could enrich this preliminary analysis and integrate upcoming publications on the subject. It would also be relevant to focus specifically on a few of

the identified clusters and detail further their methodologies and approaches with practical examples of contextual implementations.

The concept and strategies of CE become relevant in Urban Planning and Design as they provide a starting point for radically questioning current ways of thinking, describing, and shaping cities and landscapes. For this reason, we hope that scholars, policy makers, and practitioners will increasingly embrace the ambitions of circularity on an urban scale. Within this perspective, more integrative approaches are welcomed to disentangle the complexity and to fully realise the goal of circularity. It remains the need for planners and designers to learn how to manage complex, cross-disciplinary, and potentially very large-scale processes with an increasingly high number of human and non-human actors.

Credit author statement

A. Bortolotti and G.C. Verga contributed to the conception and design of the study. A. Bortolotti and G.C. Verga performed the literature review and qualitative analysis. A. Bortolotti wrote a significant part of the first draft of the manuscript and performed the bibliometric analysis. G.C. Verga wrote sections of the manuscript. A.Z. Khan supervised part of the study. A. Bortolotti, G.C. Verga and A.Z. Khan reviewed and edited the final draft.

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