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The Circular City concept: An integrated approach

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Abstract

The research aims to deepen the concept of the Circular City as a junction space between the Circular Economy, urban metabolism and spatial development, to identify definitions and characterization to achieve the goals of sustainability and urban resilience. Thus, the article presents a literature review and the theoretical approach of the possibilities for transposing and spatial integration of the principles of the Circular Economy and the preliminary definition of the concept of the Circular City to establish the elements of distinctive competence and identify the possibilities of pragmatic application at the level of promoting a smart and sustainable urban approach.

Keywords: Circular economy, sustainability, smart, resilient, urban development.

INTRODUCTION

Cities are spaces where people live, innovate, work, and consume considerable amounts of resources, playing a fundamental role in the transition towards circular development. The main dimensions, considered as criteria for the evaluation of cities on their way to Circular Cities, are resource management, sustainable design and construction, energy efficiency and renewable energy, water management, mobility and transportation, urban agriculture and food systems, Circular Economy business models, policy and regulation, community participation, and education. At a time when

urbanization and consumption trends are exerting increasing pressure on human and natural capital, the concept of circularity is enjoying increasing attention, being considered a driver and paradigm of urban sustainability and resilience, through the provision of innovative solutions and opportunities for urban reinvention (Brglez, Perc & Lukman, 2024; Ortega Alvarado & Pettersen, 2024). In this context, the defining and characterization of urban circularity is focused on reinventing and continuously adapting the ways of organizing and operating contemporary cities to the principles of the Circular Economy, attracts the rethinking of each element of urban life to decouple from resource consumption (Herrador, 2024; Loza Adaui, 2025; Bibri, Yigitcanlar & Huang, 2025). In the context of the current deeply unsustainable spatial trends and developments of various administrative-territorial units (cities, municipalities, metropolises, or metropolitan areas), the concept of Circular City is developed by summarizing the concerns regarding the transposition of the principles of the Circular Economy in the field of spatial development.

Moreover, Circular City fosters an equitable shift from a linear to a circular economy throughout the urban environment, involving various city functions and departments, and working in partnership with residents, businesses, and the research community in regards of biodiversity, heat, air quality, energy, social and economic importance and costs. At the level of architecure and infrastructure, high sustainability ambitions were depicted all over the world. One innovative example of circular principles, and a model of sustainable urban development that has served as an inspiration around the world is the Hammarby Sjöstad, Stockholm, Sweden known as a positive collaborative process between all the community stakeholders.

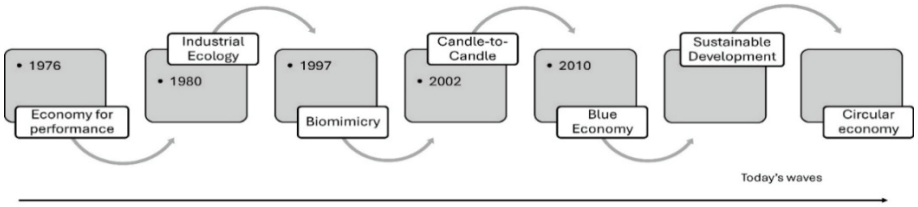
Thus, this research aims to experiment with the possibilities of spatial extrapolation of the philosophy and principles proposed by the Circular Economy and their integration into sustainable and resilient urban development practices, which can provide a new perspective and framework of the circular city. The paper is structured in three parts: (a) a literature review on concepts that will be considered when defining the Circular City concept and the approach to adopt and implement it; (b) the presentation of the conceptual framework of Circular City; (c) practical examples of two municipalities in Romania, as opportunities for operationalization and concrete approach of the Circular City. Finally, some conclusions and future work will be presented.

LITERATURE REVIEW

The circularity concept and the evolution within the legal framework

“Circularity” is increasingly on the agenda of European bodies, authorities, academia, business, and NGOs. The study of different trends and fields converging with the delimitation of the concept of Circular Economy led to the identification of some models and dominants of the development of the concept. The succession of different schools of thought led to the focus of concerns on different themes, as shown in Figure 1, and which analyzed and defined fundamental principles for transposing the reasoning of the functioning of living organisms at the level of economic and industrial systems (Szabó et al., 2024; Brglez, Perc & Lukman, 2024; Herrador, 2024; Bibri, Yigitcanlar & Huang, 2025).

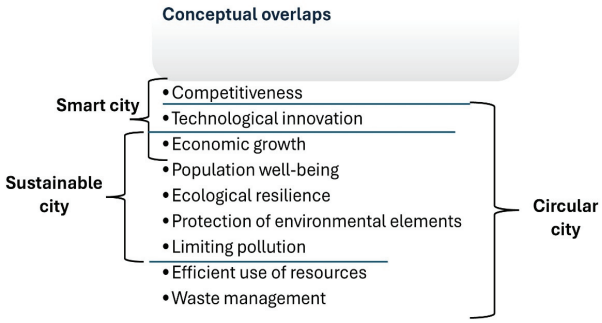
Picture 1: Areas convergent to Circular Economy (a synthesis based on the literature review).



Subsequently, the Circular Economy recorded an upward trajectory, the year 2010 marking the establishment of the Ellen MacArthur Foundation (https://www.ellenmacarthurfoundation.org/), dedicated to the development and promotion of the Circular Economy concept, with the main objective of accelerating the transition to a circular approach extended to be applied in to social and economic life, accompany by the general concern for sustainable development. The Ellen MacArthur Foundation's Circular Design Guide (2016) focuses on three key aspects to promote sustainable design and Circular Economy principles. These include: (1) Designing out waste and pollution by creating products/systems that minimize waste and pollution throughout their lifecycle; (2) keeping products and materials in use, by designing products/systems that can be easily repaired, reused, or recycled; and (3) regenerating natural systems, by ensuring that design practices contribute positively to the environment and natural ecosystems.

Literature and regulatory frameworks present the characteristics of development of the "city of the future", as an ideological approach to urban complexity; thus, a new cumulative paradigm is launched of the implications proposed by the sum of recent concepts regarding urban development. It proposes a univocal vision regarding the common good, and demonstrates how Circular City, smart cities and sustainable cities cannot be superimposed and assimilated concepts (Citaristi, 2022; UN-HABIT, 2024). As a result, to ensure coherence regarding spatial development and efficient use of resources, it can be observed that the "city of the future" must integrate, through a logical phasing, the advantages of the different projects implemented to optimize the individual dimensions proposed (Figure 2).

Picture 2: Dimensions of the smart, sustainable and circular city (a synthesis based on literature).



Author's own development.

The European Initiatives for Circular Cities

In contrast to the evolving optimism registered at European level regarding the approach to "circularity" as a means of achieving the goals of resilience and sustainability, the concept of Circular City is still in its early stages of definition and regulation. Furthermore, the Circular City has been observed to propose

a new perspective on urban systems, placing the efficiency of resource use as a transversal principle applicable to all constitutive areas of cities. In addition, without seeking to deepen the implications of social space, we note how "circular" reasoning engages structural changes in mental and behavioral terms, thus influencing the interactions and activities of today's society. Therefore, we can conclude that "circularity" is a defining characteristic of human processes.

Even if the conceptual perspectives of the Circular City animate the imagination of specialists, we note how the definition and detailed identification of the intrinsic implications is a challenging exercise considering the diversity of local specificities. However, it has been noted that the framework documents at the European level recognize the importance of cities and metropolitan areas in the transition process from the linear model of production and consumption to a "circular" one, considering them key factors for success.

In addition to environmental concerns, the need to reassess the way materials and energy are used at the urban level was highlighted in the study by the Economic Commission for Europe of the United Nations (UNECE, 2020). This can be considered the starting point of the dynamics recorded around the notion of 'circularity' and its transposition at the level of urban processes, opening a series of directions for discussion, analysis, and regulation of the circular 'city concept'. Furthermore, the European Commission is launching at the end of 2020 the European Declaration on Circular Cities (ICLEI, 2020), an initiative that aims to accelerate the transition to a Circular Economy and to outline a common vision on the concept of a Circular City by facilitating the exchange of experience between different actors. To support this, the European Green Deal (EC, 2015) promotes the efforts of the EU regarding the transition to “circularity”, considering that this process is challenging, timely, and necessary for today’s cities. Finally, with the adoption of the Paris Agreement (2015), the concept of circular economy is recognized as a premise for reducing the carbon footprint and ensuring zero-emission energy.

At the same time, the Circular Economy Package (EC, 2025a) has been linked to the EU Urban Agenda (EC, 2025b), as an emerging topic of 'Cities and urban development' and places cities at the centre, with one of the main objectives referring to recycling municipal waste by up to 55% by 2025 and 65% by 2035. The Urban Agenda represents the joint effort of the multi-stakeholders of EC and policy makers at the national level to strengthen policies targeting urban areas, within which 12 partnerships have been launched, one of which is dedicated to circularity. As evidence of the real interest enjoyed by the Circular City, a synthesis of the dimensions provided by different European initiatives and the legal framework; proves the real support for the urban transition to circularity; it can be concluded that actual studies are still struggling with the concept of Circular City application, with substantial efforts and contributions provided by the Ellen MacArthur Foundation.

THE CONCEPTUAL FRAMEWORK OF CIRCULAR CITY

Preliminary Considerations

The circular city aims to integrate the differences in sectoral dynamics in reciprocal causal relationships, a context that requires the articulation of a transdisciplinary way of thinking and the participation of a wide range of specialists. Therefore, as mentioned in the literature, the integration of circularity into urban evolution is conditioned by the existence of a transdisciplinary framework for addressing technical details, establishing a common way of action, collaboration and co-creation in view of urban reindustrialization towards circularity. Starting from the quality of cities, as 'organisms' in constant

change, it is important to establish and adopt long-term legal planning frameworks related to the dynamics, diversity, and flexibility of land uses (Fusco Girard & Nocca, 2019). In addition, cities are conditioned by the existence and effectiveness of production systems in their transition to circularity by closing material and energy loops. Thus, understanding the role of production and the need to highlight it at the level of specialized documentation requires a thorough understanding of the spatial dynamics of resources (Levoso et al., 2020; Anttiroiko, 2023). Furthermore, the research of (Croxford et al., 2020) presents a framework for facilitating sectoral interactions from the perspective of the three major components (Table 1).

Table 1: Components of circularity (the framework for facilitating sectoral interactions).

Component	Description
TECHNICAL COMPONENT	Deepening circularity is orientated towards understanding the ways of extracting, processing, and managing material or immaterial flows, mediated by technological means, know-how, and technical skills. • The metabolic approach to cities, combined with circular economy principles and the aims of sustainability and resilience, offers new ways to interpret urban spaces (Fusco Girard & Nocca, 2019). Furthermore, Croxford (2020) highlights the importance of cities in eliminating linear processes by keeping products in use, supporting product value loops, and fostering both grassroots and top-down initiatives for material recovery and recycling. • Despite Circular Economy aspirations, promoting local production within traditional frameworks presents challenges due to resistance to innovation and hindrances to forming regenerative models. Thus, local production at the city level may not inherently facilitate the transition towards circularity.
SPATIAL COMPONENT	Identifying spaces in which circularity can be configured and establishing essential spatial characteristics (accessibility, spatial/infrastructural volumes and capacities, functional and logistical schemes, flexibility of urban structures, environmental elements, and urban form). • Fusco Girard & Nocca (2019) emphasize that **morphological research** in the context of urban circularity transitions should focus on various aspects such as building dimensions, plot typologies, urban fabric density, accessibility, mobility, and landscape elements. These analyses can help identify optimal locations for production areas and necessary interventions for functional reconciliation and attractive living environments. • Traditionally, production activities were seen as incompatible with other urban functions due to pollution and traffic concerns. Two major trends in production processes are identified: concentration in peri-urban production hubs; punctual reintegration into urban enterprises due to technological advancements and cleaner production processes. • Fusco Girard & Nocca (2019) differentiate three patterns of urban production: retail production in central urban areas; mass production in peri-urban areas; mixed production along major circulation arteries. These patterns are influenced by factors like infrastructure availability, urban density, proximity, accessibility, and spatiality.
SOCIO-INSTITUTIONAL COMPONENT	The most complex and sensitive approach to circularity is dedicated to understanding human interaction with technology, culture, space, financing mechanisms, economic dynamics, and production processes. • The city is dependent on production, and production considered essential to the urban transition towards circularity underlines the importance of the workforce at the city level. • We support the hypothesis issued by (Fusco Girard & Nocca, 2019) who recognizes that the fundamental role in attracting and maintaining production activities is held by the public authority capable of correcting and reorienting market trends through planning tools and development policies. Its collaboration with the private sector to support innovation, diversification, and professionalization of the business environment, economic planning, education, and training ensures the fundamental conditions for the development and maintenance of the business environment.

A synthesis from (Fusco Girard & Nocca, 2019; Croxford et al., 2020).

Circular city framework considering the SO 37120:2020 standard

The introduction of the ISO 37120:2018 standard for "Sustainable cities and communities - Indicators for city services and quality of life" has introduced a set of indicators for measuring the performance of urban services (most related to their sustainability and smart development aspects). As has been estimated and confirmed by the public administration practices, ISO 37120 can significantly impact the development and implementation of the Circular City concept, as following:

1. By introducing a standardized metrics, ISO 37120 provides a comprehensive set of indicators that measure various aspects of urban sustainability, including environmental, economic, and social dimensions which should be considered from SDG (the 17 United Nations Sustainable Development Goals) and ESG frameworks (ESG reporting are used by organizations for the disclosure of data covering their operations and opportunities and risks that are related to the environmental, social and governance (ESG)). Thus, ISO 37120 standardized metrics support cities assessing their performance and identify areas for improvement, which plays an important role in developing circular city initiatives;
2. Performance evaluation is related not only to the suggested indicators assessment but also to their dynamic analysis which reflects their progress towards sustainability goals (SDG and ESG aspects included in an integrated manner) and Circular Economy principles. The performance evaluation has an important role in increasing the quality, effectiveness and efficiency of the decision-making process and prioritizing actions that support a more sustainable and circular urban environment;
3. ISO 37120 standard allows cities to compare their sustainability performance with other cities globally; this benchmarking approach can inspire cities to adopt best practices and innovative solutions from other successful circular city projects;
4. ISO 37120 indicators can guide local policymakers and urban planners in designing strategies and policies that promote Circular Economy principles, with respect to SDG and ESG approaches and frameworks, too. Thus, circularity is integrated into urban development plans and projects;
5. ISO 37120 indicators can be used to engage citizens and stakeholders in sustainability and Circular Economy efforts. By providing periodically transparent progress reports, cities can foster a sense of ownership and participation among citizens, encouraging them to contribute to circular initiatives;
6. ISO 37120 emphasizes efficient resource management, which is a core principle of the Circular Economy. By considering the standards indicators, cities can optimize the use of resources, reduce waste, and promote recycling and reuse practices.

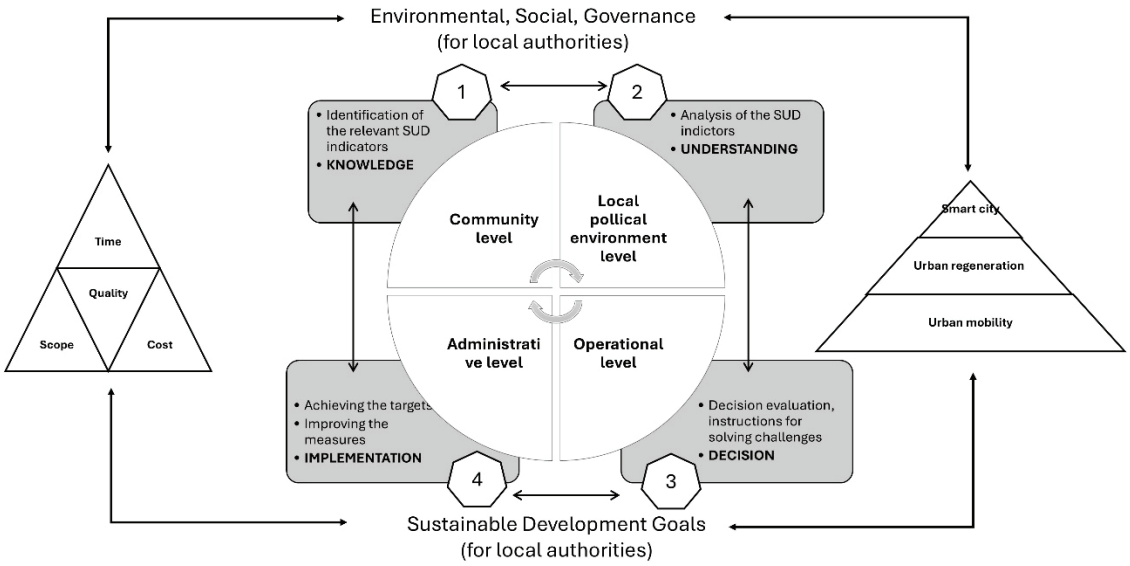
Circular City framework

As a preliminary conclusion, ISO 37120 is considered a valuable tool for cities aiming to transition towards a Circular Economy, providing a structured approach to measure, evaluate, and improve their sustainability efforts. Thus, identification of the right urban indicators at the community level and their consideration in the urban development plans and projects, reflected in the strategic documents by the political factors, provides solutions at the executive level to achieve the targets assumed and adopted at the administrative level. Considering the urban services development practices, this process should be a cyclical one according to the four pillars that underline the development of indicators for urban services (Figure 3):

- Community/knowledge: Identification of urban sustainability indicators at the level of an urban community;
- Political factor/understanding: analysis of sustainability indicators, redefining and updating strategic documents at the political level;
- Executive level/decision: evaluation of decisions, instructions and ways to solve challenges;
- Administrative level/adoption: achievement of the proposed targets at the local level. Improving sustainability measures and implementing sustainability indicators.

The conceptual framework of the "'circular city" based on sustainable urban development approach (considering ISO 37120) is shown in Figure 4 and it includes: (1) Creation of ISO 37120 database platform for collecting the indicators (statistical data) by contacting institutions authorized to provide them; (2) Identification of opportunities and target setting by data analysis, estimations and forecasting (considering the local conditions and specifics); (3) Identifying a portfolio of projects, as tools through which targets are achieved for core and complementary indicators.

Picture 3: The conceptual framework of the Circular City based on sustainable urban development approach and the ISO 37120 adoption.



CONCLUSIONS

A has been described in the research, the concept of the Circular City has been debated as a juncture between the Circular Economy, urban metabolism, and spatial development of the urban areas, focusing to achieve sustainability and urban resilience. In the literature reviews and the theoretical approaches for integrating Circular Economy principles into urban spaces there have been providing a preliminary definition and identifying practical application possibilities. Furthermore, the "city of the future" concept has been described as an integrated one, based on smart, sustainable and circular city concepts. The analysis of the European initiatives for Circular Cities has been discussed in accordance with European Green Deal (that supports efforts towards circularity, with the Circular Economy recognized as key to reducing the carbon footprint) and the EU Urban Agenda (that emphasizes recycling municipal waste and integrates circularity into urban policies). These aspects have been associated and discussed

within the context of the efforts of implementing ISO 37120:2018 standard. Finally, the Circular City framework has been defined. The main advantages of implementing the proposed approach (Figure 3) are systematic and data-driven approach to addressing sustainability challenges; improved ESG practices and outcomes; increase efficiency and effectiveness of urban planning and development; enhanced long-term urban sustainability having a great potential for new projects implementation (urban developement via investment).

Future research will be focus on operationalization of the proposed Circular City framework supported by an software tool and its testing and validation via different use cases.

REFERENCES

Anttiroiko, A. V. (2023). Smart circular cities: governing the relationality, spatiality, and digitality in the promotion of circular economy in an urban region. *Sustainability*, *15*(17), 12680.

Brglez, K., Perc, M., & Lukman, R. K. (2024). The complexity and interconnectedness of circular cities and the circular economy for sustainability. *Sustainable Development*, *32*(3), 2049-2065.

Bibri, S. E., Yigitcanlar, T., & Huang, J. (2025). *Digital Twins for Smart Metabolic Circular Cities: Innovations in Planning and Climate Resilience.* Smart Cities Book Series. Elsevier.

Citaristi, I. (2022). United nations human settlements programme—UN-habitat. In *The Europa Directory of International Organizations 2022* (pp. 240-243). Routledge.

Croxford, B., Domenech, T., Hausleitner, B., Hill, A. V., Meyer, H., Orban, A., Sanz, V. M., Vanin, F., & Warden, J. (2020). *FOUNDRIES OF THE FUTURE: A Guide for 21st Century Cities of Making: a Guide to 21st Century Cities of Making*. TU Delft OPEN Publishing. https://doi.org/10.47982/BookRxiv.9

EC (2015). *The European Green Deal*., Retrieved from: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en (Access on 05.02.2025).

EC (2025a). *Circular economy*. Retrieved from: https://www.consilium.europa.eu/ro/policies/circular-economy/ (Access on 05.02.2025).

EC (2025b). Urban Agenda for the EU. Retrieved from: https://commission.europa.eu/eu-regional-and-urban-development/topics/cities-and-urban-development/urban-agenda-eu_en (Access on 05.02.2025).

Ellen MacArthur Foundation (2016). *Circular Design Guide*. Retrieved from: https://www.ellenmacarthurfoundation.org/circular-design-guide/overview (Access on 05.02.2025).

Fusco Girard, L., & Nocca, F. (2019). Moving towards the circular economy/city model: which tools for operationalizing this model?. *Sustainability*, *11*(22), 6253.

Herrador, M. (2024). A Universal Circular Cities Declaration to Achieve Global Sustainability. Resources, Conservation and Recycling, 209, 107757.

ICLEI (2020). *The European Circular Cities Declaration*. Retrieved from: https://circularcitiesdeclaration.eu/about/about-the-declaration (Access on 05.02.2025).

Levoso, A. S., Gasol, C. M., Martínez-Blanco, J., … & Gaya, R. F. (2020). Methodological framework for the implementation of circular economy in urban systems. *Journal of Cleaner Production*, *248*, 119227.

Ortega Alvarado, I. A., & Pettersen, I. N. (2024). The role given to citizens in shaping a circular city. *Urban Geography*, *45*(4), 611-630.

Szabó, M., Gimkiewicz, J., Cappellaro, F., Innella, C., & Csigéné Nagypál, N. (2024). Transition to circular economy of urban areas and communities with special attention to lifestyles. *Discover Sustainability*, *5*(1), 482.

UNECE (2020). *A Guide to Circular Cities.* Retrieved from: https://unece.org/info/publications/pub/21969 (Access on 05.02.2025).

UN-HABIT (2024). *World Cities Report 2024: Cities and Climate Action*. Retrieved from: https://unhabitat.org/world-cities-report-2024-cities-and-climate-action (Access on 05.02.2025).

Winslow, J., & Coenen, L. (2023). Sustainability transitions to circular cities: experimentation between urban vitalism and mechanism. *Cities*, *142*, 104531.