Cities on Circular Economy: Urban Strategies based on the study of pioneering local experiences

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Abstract. Today's society is in a critical situation: the prevailing linear model of the economy has led to an overexploitation of natural resources, and it has generated environmental impacts that affect the health of all living beings. An economic model of a cyclical nature, or circular economy, is presented as a solution in this situation. This form of economy facilitates the optimization of the useful life of materials, reducing the environmental impact, allowing products and materials to retain their value throughout the production and use cycle. The main purpose of this work is to identify urban strategies carried out by local experiences in pioneering cities that are actively committed to the development of a circular economy as an economic model of society. Cases such as Amsterdam, London, Paris or Milan stand out. The ultimate goal is to show examples that can inspire other cities and local governments to implement measures towards this new model of economy and urban development. The study of local cases throughout the strategies carried out has made possible to establish relationships between the different experiences analysed and to identify the areas with the greatest development and those in which there is less experience. Efficient waste management is one of the most explored areas and where a greater number of local initiatives have been identified. But alongside this, there are other areas that need to be explored: the efficient management of water resources, energy, or food in the city. In response to these, some urban strategies stand out: regeneration of public spaces, sustainable mobility infrastructures, renaturation of urban environments, urban limits, integration of pre-existences, citizen participation and governance are some of them. The contribution of the work focuses on the identification and classification of a whole series of urban strategies already implemented for their possible transfer to other environments.

1. Introduction
During the last decades, the consumption of raw materials has reached a rate that, without a doubt, compromises the load capacity of the planet if the current linear model of production and consumption cannot be stopped or changed. The uncontrolled use of the finite resources of nature endangers their availability for the future, in addition to receiving negative impacts on the environment. The linear scheme prevailing in society as an economic model, based on the extraction, consumption and elimination of products and materials is not sustainable over time. The large number of products and materials that are destined to become a landfill deposit, instead of reincorporating them to productive circuits, leads to the depletion of systems in nature. The antagonism between human beings and the physical environment that surrounds them takes on a greatly exaggerated scale, due to increasingly selfish behaviour. This reality is a description of contemporary civilization, which will destroy ecosystems and life on earth. In this context, the circular economy (CE) is presented as the alternative to this linear model, responding in a way, to the various sustainable problems that appear due to current
economic growth, allowing a cyclical flow of materials and products from extraction, distribution, use and subsequent recovery. The concept of circular economy becomes a paradigm of action that has evolved from the concept of sustainability and its application in the economy, society and the environment [1].

By 2050, 68% of the world's population will live in cities [2], with urban environments responsible for ¾ parts of greenhouse gas emissions. It is crucial, to reduce emissions, the steps and measures taken in cities, as stated in the Paris Agreement on climate change [3]. The Global Covenant of Mayors [4] brings together more than 10,000 cities, where local governments, plans and tools play a fundamental role.

The path to a circular economy has started in different countries. Europe is where the greatest initiatives are concentrated by the joint work of political entities, companies and local communities. In general, these are fully focused on transforming the current linear economic model into a circular one. The European Commission urges cities to promote circularity strategies through a “Closing the Loop” action plan [5]. In order to understand how cities can be circular, some previous studies have identified in a timely manner pioneering initiatives in the international context [6], [7], [8] as described in paragraph 2.

The main purpose of this work is to identify urban strategies carried out by local experiences in pioneering cities that are actively committed to the development of a circular economy as an economic model of society. The ultimate goal is to show examples that can inspire other cities and local governments to implement measures towards this new model of economy and urban development. The analysis of the case studies provides, compared to other studies previously carried out, a related analysis of the different cases based on the urban strategies.

2. Previous research and experiences

From scientific research, recent works show this concern on the part of local administrations, entities, and citizens in general, as well as they have developed some case studies and actions carried out in cities aimed at promoting a circular economy. The work of Lindner et al. [6] is of interest by showing emerging initiatives developed or supported by local entities and administrations, inviting other administrations to undertake circular actions of this type. This work shows very different experiences: from digital platforms to share resources between different agents, recovery and renovation policies in the obsolete housing stock, business models that promote the reuse and repair of products, programs and business incubators for developing circular economy within their cities, or urban development projects and circular solutions for waste, energy and water recovery.

Montagner Augé [8] shows some successful initiatives and strategies in different Spanish cities, which affect the different urban metabolic flows: 1-materials and solid waste, 2-water, 3-energy, and 4-biological cycles and biodiversity. This relationship between flows and strategies is transferred to this research, which allows establishing relationships between case studies and advancing some first conclusions regarding the management of flows and their circularity. The study by Prendeville et al. [9] does a very interesting job by showing 6 cities in transition towards a circular economy (Amsterdam, Rotterdam, Haarlemmermeer, Glasgow, The Hague and Barcelona) through common policy strategies that have been identified.

It should also be noted the work of some local administrations in the preparation of plans and programs to implement a circular economy in their respective cities. The “Circular London” program focuses on the issues of recycling materials, as well as the regeneration of urban spaces through “circular” houses and ecological urban planning proposals [10]. The “container city” project is part of this program, being a neighbourhood built with shipping containers in a former port area known as
Trinity Buoy Wharf located in East London [11]. The “FoodSave” initiative, from the same “Circular London” program, was launched in November 2013, to help small and medium-sized food businesses reduce food waste, make the most of leftover food and eliminate the inevitable waste of food through processes such as composting or anaerobic digestion [12].

Also noteworthy is the “Plastic-Free Hackney” project, a community created in a London neighbourhood by Bettina Maidment who decided to end life with plastic and began spreading her idea throughout the district. Starting in 2017 with such an idea, the first store in the country has been created in the area where all the products they offer are sold in bulk without the need to use plastics, thus being the first neighbourhood in this country to develop a fight against plastics [13]. This list of London initiatives is joined by the city of Peterborough, north of London. This city aims to close the circle by eliminating the concept of waste and becoming the first circular city in the United Kingdom [14].

The city of Paris stands out for its work in the development of the “White Paper: Circular Economy in Cities” [15], a guide to achieve a sustainable economic model, developing multiple proposals that support companies and the city in general towards a circular economy. Participatory work between agents involved acquires a fundamental role. This program highlights experiences such as "La rue de Paradis", in Paris, which was the scene of the Garbage 0 operation. This lasted one year (December 2018 to December 2019) and its objective was to help the residents of the neighbourhood to reduce the amount of waste they generated in their day to day, learning good practices and trying some effective measures in waste management [16].

The city of Milan also excels in this path towards a circular economy. The “Awesome Foundation” develops important works with the aim of reducing waste. One of these jobs is the one they develop in the markets of the neighbourhoods of Milan, called “Recup”. The main objective of the program is to eliminate the volumes of waste from food in these markets, achieving a very important social implication. The Italian city has become an international benchmark in terms of waste management, with a commitment to treatment in composting and anaerobic digestion facilities [17].

In the field of waste management, the experience of San Francisco city also stands out through the “Zero Waste” project, an important collaborative initiative whose main objective is to completely eliminate the waste generated in the city. Everyone in San Francisco is obliged to separate the garbage they generate by categories [18].

The city of Singapore is known to be the emblem of Asian green cities. The fundamental work of the commitment to sustainability in this country is the reuse of water and its efficient management. Singapore, a small country of modern skyscrapers, has in recent years become a great laboratory for sustainability and CE, with innovative projects that are attracting many foreign companies to Asia, to join the challenge of environmental progress facing the climate crisis [19].

The city of Amsterdam has been awarded many times for its work in support of sustainability and its commitment to a CE. It is also an example of an eco-intelligent city, developing the concept “From the Cradle to the Cradle”. An exemplary agenda guides the work of the city in this sense, called “Circular Amsterdam” to achieve a fully circular economy by 2050. It is committed to the use of bicycles and public transport as an alternative for mobility, to the production of renewable energies, to a construction that uses recycled materials, to an urbanism that reintegrates the abandoned areas with new urban settlements, and to an efficient management of the water resource and the treatment of wastewater [20].

3. Methods
Based on a bibliographic review for the identification of case studies, an analysis of the different cases has been carried out, a series of urban strategies developed by each of them have been extracted and
they have been classified according to their relationship with the following metabolic urban flows: 1-materials and solid waste, 2-energy, 3-water, and 4-biological cycles and biodiversity.

The strategies, therefore, have been established from a previous analysis of the different case studies. Finally, a table has been constructed that allows relating the different cases through the implemented strategies and outlining some first conclusions and keys to encourage circularity in cities.

4. Results and discussions
The concept of urban metabolism involves looking at cities as living beings [21]. As in nature, cities require resources such as food, water or energy to live. The physiological processes that occur in living beings are compared with urban metabolic flows. The strategies analysed in the different case studies are aligned with the objective of achieving a circular metabolism, where the management of resources (whether energy, water or others) does not generate waste but rather substances that return to the circuit and comply with other functions in the ecosystem. These metabolic flows or the consideration of resources such as materials and solid waste, energy, water and biological cycles, has allowed to order and classify the different urban strategies in the 17 analysed cases.

This table of strategies and case studies (see Table 1) is considered an open document that can be expanded in future research. In this work, 17 case studies have been considered, 26 urban strategies have been obtained from analysis: 11 of them in relation to metabolic flow of materials and solid waste, 3 in response to metabolic flow of energy, 3 in in relation to metabolic flow of water, 7 in relation to metabolic flow 4 of biological cycles and biodiversity, and 2 of them in relation to the concept of Citizen Participation and Governance.

Table 1. Urban strategies and case studies towards a circular economy

| Metabolic Flow 1: Materials and Solid Waste | LOCAL INITIATIVES IN CITIES |
|-------------------------------------------|-----------------------------|
| E1. Recycle and Reuse materials           | 1. Container City, London, UK |
| E2. Integrate what has been built with pre-existence | 2. Plastic Free Hackney, London, UK |
| E3. Separate organic waste at source      | 3. Food save Program, London, UK |
| E4. Activate composting processes         | 4. Peterborough, UK |
| E5. Activate anaerobic digestion processes| 5. White Paper on Circular Economy, Paris |
| E6. Use modular systems in homes and facilities | 6. The rue de Paradis, in Paris |
| E7. Waste management in Milan             | 7. Recup Project, Milan |
| E8. Zero Waste, San Francisco             | 8. Waste management in Milan |
| E9. Green cities, Singapore               | 9. Zero Waste, San Francisco |
| E10. Circular Amsterdam                   | 10. Green cities, Singapore |
| E11. Circular Ámsterdam                   | 11. Circular Amsterdam |
| E12. Aviles Vivas y Cubiertas Verdes, Barcelona | 12. Aviles Vivas y Cubiertas Verdes, Barcelona |
| E13. Parque de Malilla, en Valencia       | 13. Parque de Malilla, en Valencia |
| E14. Anillo Verde, Vitoria                | 14. Anillo Verde, Vitoria |
| E15. Copenhagen-Chaelsea Plan             | 15. Copenhagen-Chaelsea Plan |
| E16. municipios en Aroa, Cataluña         | 16. municipios en Aroa, Cataluña |
| E17. Eucinastia, Barcelona                | 17. Eucinastia, Barcelona |

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4.1. Metabolic flow 1: Materials and Solid Waste
It is highlighted that all the case studies, except for one of them, have carried out urban strategies related to the management of materials and solid waste. On this path towards a circular economy, cities in transition give priority to circular waste management. Strategy 1 of recycling and reusing materials is a constant in pioneer cities: London, Paris, Milan, Amsterdam, San Francisco or Singapore have incorporated policies and measures in this regard.

The urban strategy 2 of integrating the built with the existing elements, acquires importance and it is repeated in 6 case studies. It is essential to incorporate this premise in urban planning and projects. Cities such as London, Vitoria, Barcelona and Copenhagen have developed territorial and urban proposals based on the consideration of their pre-existences in order to integrate and enhance them in contemporary proposals.
Strategy 7: designing spaces for waste, is repeated in up to 5 of the analysed cases, which indicates the importance of considering this aspect in the urban design and planning phases. Milan, Paris, Amsterdam, San Francisco, and Singapore have made a clear commitment in this regard.

The interest of different cities and initiatives to eliminate the use of single-use plastics is highlighted. In some cases, this strategy has been carried out from bottom-up initiatives, as in the case of “Plastic free Hackney”, in London. In other cases, local administrations themselves have implemented this strategy through plans and agendas.

4.2. Metabolic flow 2: Energy
In relation to the management of energy resources, 3 clear strategies have been identified in the analysis of the different case studies. The use of renewable energies is a bet of these cities in transition: Amsterdam, Barcelona, Paris, Peterborough and Singapore. The use of finite fuels is incompatible with the closure of production cycles. The transition towards renewable energies is an unavoidable issue in circular urbanism [8].

Two other strategies related to mobility are identified: promoting the use of bicycles as an alternative to transport, and the use of public transport versus the use of private vehicles. Many cities, and especially since the COVID 19 pandemic, have expanded their network of bike lanes. We must not forget that in cities the main energy consumption is related to mobility and it is essential that urban agendas can be updated and incorporate the urgent need to change their mobility models. In this sense, cities like Amsterdam or Vitoria are an excellent reference for other local administrations.

4.3. Metabolic flow 3: Water
Water resource management is directly related to three urban strategies: efficiently managing drinking water, reusing wastewater and rainwater, and channelling runoff water to natural lands. From the analysis of the case studies, and specifically of cities such as Amsterdam, Vitoria or Copenhagen, the importance of considering the ecological processes of water in urban planning itself is highlighted.

Traditionally, urban processes and settlements have washed away natural water runoff; Soils have been massively waterproofed in urbanization processes, natural channels have been artificially channelled, intervening on the natural dynamics of water, and water has been collected through pipes and a sewage system. Against this, some cities are betting on the natural recovering of the rivers, the permeabilization of the soil and the restoration of the natural processes and dynamics of the water. The Copenhagen Cloudburst Plan [22] highlights the need to incorporate these principles into city planning, with significant urban, social and environmental improvements.

4.4. Metabolic flow 4: life cycles and biodiversity
Cities tend to be environments with a low level of biodiversity, where biological cycles are greatly simplified (8) due to the scarcity of fertile areas, and, as already mentioned, the high surface area of impermeable lands as a result of the processes of traditional urbanization. The strategies identified are related to the interest of favouring these biological cycles in urban environments. The E18 strategy of conceiving green roofs is a measure that some cities are already incorporating into their urban and environmental policies. The case of Barcelona stands out, through the “Living Roofs and Green Roofs Plan” [23]. The roofs become an opportunity space to produce renewable energies and new green spaces in the city.

The strategies of connecting natural spaces and introducing green spaces rich in biodiversity in urban environments are already part of the territorial and urban planning policies of many cities. The incorporation of green infrastructures within the planning itself has made great progress in recent years.
The example of Vitoria's green ring stands out, elected “green capital” in 2012, and “global green city” in 2019.

4.5. Citizen participation and governance

From the analysis of the case studies, it can be seen how collaborative strategies and citizen participation are carried out in all of them. Community work and together with local administrations is essential in the different success stories. We can say that citizen participation and governance is a key tool in circular economy processes; some of the initiatives are initiated by local communities and, later on, are supported by local administrations. In other cases, the administrations establish specific programs towards a circular economy, as in the cases of London, Amsterdam, Paris, or Barcelona. In all processes, relations between citizens, associations, and companies, with administrations must be favoured and promote good communication. Education and awareness campaigns for citizens are essential for their involvement in the commitment to a circular economy.

5. Conclusions

The analysis of 17 case studies or good practices in relation to a circular economy has allowed to identify up to 26 urban strategies that encourage circularity of our cities. In this way, from specific cases, strategies and general keys can be extrapolated to other territories. The relationship between strategies and metabolic flows shows how the management of natural resources, materials and solid waste, water and energy can be worked in different ways on the urban scale. Cities with a greater commitment to a circular economy have undertaken actions and strategies in different spheres simultaneously, attending to the management of different resources.

This series of strategies and projects aims to offer a frame of reference for other cities and local administrations to know how to incorporate the circular economy into urban planning and management. It also offers a starting point for future research that wants to expand the relationship between case studies and urban strategies on circular economy.

References

[1] V. Prieto-Sandoval, C. Jaca, and M. Ormazabal. Circular economy: Relationship with the evolution of the concept of sustainability and strategies for its implementation. Mem Investig en Ing 2017. Available from: https://dadun.unav.edu/bitstream/10171/53653/1/Economia_Circular.pdf

[2] ONU: Departamento de Asuntos Económicos y Sociales. Naciones Unidas [Online]. Noticias: Las ciudades seguirán creciendo, sobre todo en los países en desarrollo. 2018. Available from: https://www.un.org/development/desa/es/news/population/2018-world-urbanization-prospects.html

[3] European Comission. The Paris Protocol – A blueprint for tackling global climate change beyond 2020 [Online] Brussels; 2015. Available from: https://ec.europa.eu/clima/sites/default/files/international/paris_protocol/docs/com_2015_81_en.pdf

[4] European Comission. Global Covenant of Mayors for Climate and Energy [Online]. Available from: https://www.globalcovenantofmayors.org/

[5] European Comission. Closing the loop - An EU action plan for the Circular Economy [Online]. Brussels; 2015. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614

[6] P. Lindner, C. Mooij, and H. Rogers. CircularEconomy in Cities around the World. A selection of Case Studies [Online]. Karlskrona, Sweden; 2017. Available from: https://www.circulareconomyclub.com/wp-content/uploads/2018/02/Report_CollectionCaseStudies2017_FinalV2-1.pdf

[7] A. Núñez-Torrón Stock. La economía circular es posible: 3 ciudades que la desarrollan con éxito
[8] C. Montaner Augé. Urbanismo circular: ¿cómo incidir en la Economía Circular desde el planeamiento, el proyecto y la gestión urbana? Forum Calid. 2018;294:18–25.
[9] S. Prenderville, E. Cherim, and N. Boeken. Circular Cities: Mapping Six Cities in Transition. Environ Innov Soc Transitions. 2018 Mar 1;26:171–94.
[10] Mayor of London and London Boroughs. ReLondon [Online]. London Waste and Recycling Board. 2020. Available from: https://relondon.gov.uk/
[11] Ciudad de los Contenedores [Online]. Wikiarquitectura 2001. Available from: https://es.wikiarquitectura.com/edificio/Container-City/.
[12] C40 Cities Climate Ladership Group. Good Practice Guide. Waste to Resources [Online]. C40 Cities. Available from: http://c40-production-images.s3.amazonaws.com/other_uploads/images/554_W2R_UPDATED_EC_15316.origina l.pdf?1458040149
[13] Plastic-Free Hackney [Online] 2020. Available from: https://plasticfreehackney.com/
[14] Fresneda C. Las siete "R" de la ciudad circular. El Mundo [Online] 2017; Available from: https://www.elmundo.es/ciencia-y-salud/ciencia/2017/07/31/597e21d3268e3eea578b457b.html
[15] Worl Economic Forum. White Paper: Circular Economy in Cities Evolving the model for a sustainable urban future [Online] 2018. Available from: White_paper_Circular_Economy_in_Cities_report_2018
[16] Fundación para la Economía Circular. Calle de “Residuo 0”: nueva iniciativa de la ciudad de París [Online]. De la cuna a la cuna. 2018. Available from: http://economiacircular.org/NL/nt/111218/noticia3.html
[17] Milán, excelencia europea en la recogida selectiva [Online]. Mater-BI 2015. Available from: https://materbi.com/es/case-history/milan-excelencia-europa-en-la-recogida-selectiva/#:~:text=Milán con el modelo puerta,que cualquier otra ciudad europea.&text=La recogida de la materia orgánica ha permitido a la,óptimo para una gran metrópolis
[18] El caso de éxito de San Francisco en la gestión de los residuos urbanos a través de la estrategia Zero Waste. RETEMA Revista Técnica de Medio Ambiente [Online] 2014; Available from: https://www.retema.es/noticia/el-caso-de-xito-de-san-francisco-en-la-gestin-de-los-residuos-urbanos-a-trav-de-la-estrategia-zero-waste
[19] EFEVerde. Singapur, un pequeño país, “laboratorio” mundial para la sostenibilidad [Online]. Factor CO2 [Online] 2019. Available from: https://www.factorco2.com/es/singapur-un-pequen-pais-laboratorio-mundial-para-la-sostenibilidad/noticia/5131.
[20] City of Amsterdam. Amsterdam Circular 2020-2025 Strategy [Online]. Amsterdam; Available from: https://assets.amsterdam.nl/publish/pages/867635/amsterdam-circular-2020-2025_strategy.pdf
[21] Rueda Palenzuela S. El Urbanismo ecológico. Urban-e [Online]. 2013;02:22. Available from: http://urban-e.aq.upm.es/pdf/El_Urbanismo_Ecologico.pdf
[22] Ramboll. Copenhagen Cloudburst Plans [Online]. 2016. Available from: https://acwi.gov/climate_wkg/minutes/Copenhagen_Cloudburst_Ramboll_April_20_2016 (4).pdf
[23] Ayuntamiento de Barcelona. Guia de azoteas vivas y cubiertas verdes BCN [Online]. Barcelona; 2015. Available from: https://media-edg.barcelona.cat/wp-content/uploads/2016/02/Guiaterrats-CAST-baixa.pdf