



Urban Circularity in Latin America and the Caribbean: A Comparative Case Study of Bogotá and Mexico City

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Abstract

Cities are implementing circular economy (CE) strategies to contribute to their environmental ambitions, including in Latin America and the Caribbean, one of the world's most rapidly growing and urbanized regions. This study investigates how the CE is envisioned in Bogotá, Colombia, and Mexico City, Mexico, and evaluates how applicable the Urban Circularity Assessment Framework is in different contexts. We find narrow CE visions and strategies in both cities, with low engagement with different stakeholder groups and limited consideration of CE impacts. While the framework applies to different contexts, it has a limited focus on contextual factors to reflect on social, cultural, and institutional characteristics. Highlighting the importance of place-based CE strategies, our study advocates for integrating technology-driven and human-centered approaches to avoid replicating similar CE misconceptions found in other cities and instead foster inclusive and sustainable urban transitions in the region.

Highlights

- Examining circular economy strategies in Bogotá and Mexico City reveals narrow visions, limited stakeholder engagement and consideration of impacts, highlighting the need for inclusive circular economy approaches.
- The study underscores the applicability of the Urban Circularity Assessment Framework across diverse contexts while emphasizing the necessity of incorporating social, cultural, and institutional factors.
- Insights from this research emphasize the importance of developing place-based circular economy strategies that integrate technology-driven and human-centered approaches to foster inclusive and sustainable urban transitions in the region.

Keywords Circular economy · Cities · Colombia · Mexico · Place sensitivity

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Introduction

Latin America and the Caribbean (LAC), a geographically diverse region, experiences one of the most rapid urbanizations globally, with more than 80% of its 665 million population currently living in cities, including five mega-cities [1, 2]. This urbanization rate is projected to reach 89% by 2050 [3]. Pressure on natural resources is high, at 12.5–14 tonnes of resources consumed per capita in 2015, and is anticipated to rise to 25 tonnes per capita – well above the range of 6–8 tonnes per capita considered sustainable [2, 4]. Escalating resource consumption and rapid urbanization present multifaceted challenges to LAC cities, including increased waste generation, environmental degradation, and pressure on urban infrastructure [4, 5]. Historically, LAC has been highly dependent on natural resource extraction, characterized by a specialization in producing and exporting agricultural and mining commodities [6]. Since 1975, biodiversity has declined by 94%, substantially above any observed biodiversity loss elsewhere [7]. Concerns about the harmful impacts of the predominant economic model on the environment and natural ecosystems have increased in the region [8]. Moreover, inequality has also been associated with the extraction of natural resources, where powerful elites have open access to critical resources and negative impacts of extraction and disposal are disseminated among territories and the population [9, 10].

In this context, the circular economy (CE) has become a popular concept to address the challenges related to the systematic crises of the Anthropocene [11]. Particularly for the region LAC, the CE is gaining popularity [12]. In contrast to the linear ‘take-make-dispose’ economic model, the CE concept has been appraised as a tool to solve the climate crisis and reduce the overall environmental impact of economic activities [13–15]. Based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems [16], it is suggested as an alternative model for production and consumption, aiming at decoupling the use of virgin resources from economic growth and thereby contributing to sustainable development [15, 17, 18]. The CE is proposed as a tool to address poverty and inequality when implemented appropriately and considering its impact on human development [8]. Benefits of the CE for cities in LAC are ample: they could halve resource consumption; build resilience to climate change; halt biodiversity loss; reduce poverty; and create a net total of 4.8 million jobs by 2030 [4, 7, 10, 19, 20]. As a consequence, the Circular Economy Coalition for Latin America and the Caribbean, set up in 2021, identified over 80 public policy initiatives [7], including national CE plans in Colombia, Uruguay, Peru, Chile, and Ecuador; as well as cities declaring to aim for increased circularity, including Bogotá, Buenos Aires, Lima, Mexico City, and Santiago [21].

However, various issues impede the successful implementation of CE initiatives in the region, as the CE concept is not well defined for the region and the literature is scarce [8, 12]. Most studies on CE in the region focus on Brazil, with waste management being the most extensively researched topic, including innovative solutions for waste management and resource utilization such as bioengineering and biochemistry [8]. The lack of studies from a Global South perspective highlights a need for inclusive CE approaches, adjusted to regional specificities and socially inclusive, combining human-centered and technology-oriented approaches [22]. Existing frameworks, predominantly developed in

the Global North, often fail to capture specific challenges to the LAC region, such as high informality rates in waste management, political instability, and the unique socio-economic contexts of rapidly urbanizing areas [23, 24]. Despite these cultural and political differences between Europe and LAC, scholars highlight that the region LAC is making similar mistakes in the implementation of the CE [8].

Indeed, scholars have found that the CE agenda has been predominantly driven by European and Chinese actors [25, 26]. Studies focusing on LAC note a lack of assessment of approaches on the macro level (countries, regions, and cities) and the potential benefits of the CE concept in countries with developing economies [27]. The 17 studies covering LAC cities (Table 1) are narrowly focused on waste management (reducing, reusing, and recycling of waste) and inclusion of informal waste workers, and lack a comprehensive assessment of how the CE could contribute to more sustainable cities [28]. To overcome the lack of a holistic framework to assess the CE at the city level [29–31], Vanhuysse [32] developed the Urban Circularity Assessment Framework (UCAF) to plan, monitor and evaluate the CE at the city level, comprising five components: (1) urban vision; (2) governance and participation; (3) CE strategies and sectors; (4) urban stocks and flows; and (5) societal impact, or impact on the triple bottom line. The next section introduces the UCAF as well as criteria for the selection and evaluation of CE frameworks on the macro-level.

With this paper, we expand the scientific literature on CE approaches in LAC cities. We have two primary aims: (1) critically review how the CE is envisioned and designed in Bogotá and Mexico City, to understand whether these cities are undergoing similar trajectories as cities in other countries, and adhere to a technocratic, positive viewpoint of the CE; and (2) test whether the UCAF applies to these two cities in LAC and is adaptable to their unique contexts. By focusing on Bogotá and Mexico City, two rapidly growing cities that have signed the Circular Cities Declaration with the ambition to drive the CE transition in the region, we aim to provide insights that can inform CE strategies in other LAC urban areas [21, 45]. While our focus is limited to two cities in the region, the insights gained from Bogotá and Mexico City can serve as a starting point for understanding broader trends and challenges in CE adoption across the region, while also highlighting the importance of tailoring approaches to specific local contexts. In Sect. 2, we provide more detail on these case studies. Our main research questions and sub-questions are:

- RQ1) How is the CE envisioned in Bogotá and Mexico City?

RQ1.1) What are the key priorities in each city, including CE strategies, sectors and main stakeholders?

RQ1.2) What gaps can be identified in the current CE approaches of Bogotá and Mexico City through the mapping against the UCAF?

- RQ2) To what extent does the UCAF consider local context and which lessons can be derived from applying the UCAF in LAC?

Our contribution is threefold. Firstly, our study adds to the emerging body of scientific literature on CE approaches in LAC cities. Secondly, through our case study analysis

Table 1 Overview of circular cities studies in LAC

Country	City	Summary findings
Argentina	Buenos Aires	In a study on waste picker cooperatives and peasant organizations in Argentina, Becerra et al. [9] explore how to integrate CE principles with the development of technological solutions. The authors find that CE principles hold great potential to contribute to inclusive development when integrated in bottom-up, collaborative, and innovative dynamics.
	Chaco	
	Mar de Plata	
Brazil	Espírito Santo	The study by Siman et al. [34] aims at strengthening Brazilian Waste Picker Organizations through the application of corporate governance tools, increasing the efficiency of recycling and urban waste management. The results indicate that the main activities influencing market efficiency are selective collection, reception of the solid recyclable waste, sorting, pressing, baling, and the commercialization of selected waste.
	Florianopolis	The study by Andrade Junior et al. [35] addresses how the extent of greenhouse gas (GHG) emissions from a municipal solid waste system can be improved by increasing wastepaper recycling. It shows that 41% of the climate change impacts from wastepaper management could be reduced when increasing the wastepaper recycling rates and reducing wastepaper landfilling.
	Londrina	Miranda et al. [22] address the inclusion of recycling cooperatives in the formal management of municipal solid waste with recyclable potential. The findings indicate that the implementation of the CE in developing countries is conditioned to the performance of the informal sector and that the inclusion of cooperatives can improve recycling rates.
	Rio de Janeiro	Otoni et al. [36] conduct a scenario analysis to support decision-makers in e-waste management. The authors identify Rio de Janeiro as the biggest e-waste producer, with 127 tonnes/day and 251 collection points.
Bolivia	La Paz	Ferronato et al. [37] address issues around municipal solid waste management in La Paz. They find inefficiencies in collection, recycling, financial sustainability, and equity of the municipal solid waste management service.
	La Paz	In another study with different selective collection scenarios, the authors find that in the scenario considering the inclusion of informal recycling the recycling rate increased by about 10% [38].
Chile	42 Chilean municipalities	Valenzuela-Levi [39] studies factors influencing the recycling rate of Chilean municipalities, identifying the existence of kerbside separate collection, duration of recycling programs and per capita spending on waste management as significantly positive factors for separate collection rates.
	Concepcion Santiago	See, Barragán-Escandón et al. [33] De Kraker et al. [40] explore the possibilities for decentralized recovery of nutrients from residual flows in Santiago. The findings indicate that decentralized valorization of kitchen waste and garden residues presents a win-win due to cost savings in comparison to current practices.
Ecuador	Cuenca	In a study on waste pickers in Cuenca, Burneo et al. [41] find that on average a recycler contributes to the prevention of 0.48 metric tonnes of carbon dioxide equivalent (tCO _{2e}) per tonne of recycled material and that the socioeconomic profile shows limitations of basic services, education, health food and housing.

Table 1 (continued)

Country	City	Summary findings
Guatemala	Guatemala City	In a study on Guatemala City, Kumble [42] suggests how to contribute to CE principles in the composting business through community service learning and action research.
Mexico	Guadalajara	Espindola et al. [43] stress the importance of rainwater harvesting, and using rainwater catchment systems thereby decreasing the cost of damages caused by floods, decreasing the demand for water and reducing the cost of production.
	San Cristóbal de las Casas	The study by Gonzalez Veuglers [44] explores solutions for different types of urban solid waste for value recovery, stressing the need for a holistic waste management system including waste separation schemes and logistic networks for waste treatment.
	Tijuana	See, Barragán-Escandón et al. [33]

Source: Based on the evidence map by Vanhuysse et al. [28]

of Bogotá and Mexico City, we uncover whether LAC cities are taking similar stances towards the CE as European ones, potentially leading to similar mistakes in approaches. In the context of Europe, scholars have stressed the lack of holistic CE approaches with positive technocratic viewpoints, failing to understand the potential negative consequences of the CE [46]. Scholars note that particularly for LAC cities, considering the social impacts of CE strategies and ensuring a socially inclusive CE transition could tackle inequality and poverty in the region [8, 22]. Thirdly, through the case studies, we uncover whether the UCAF, holds for non-European cities and if the framework has been developed with place-based sensitivity in mind. Scholars contrast spatially blind versus place-based approaches for regional development interventions, stressing the need for place-based sensitivity to avoid simplistic and inefficient policies [47]. A place-based approach underlines the relevance of geographical context, where context is understood in terms of its social, cultural, and institutional characteristics [47], beyond a one-size-fits-all approach [48]. Another dimension of a place-based approach is the issue of knowledge in policy intervention, integrating new knowledge and ideas through the interaction of local groups and external elites to avoid social exclusion [47]. In this context, passive beneficiaries of a policy should become active partners and drivers of its development [49], and the development of a strategy should become a performative process, where diverse stakeholders commit to a shared goal [50]. A report on development issues in LAC [51], endorsing place-based approaches, highlights the promotion of integrated policies for each territory, with attention to the needs of cities, city regions, and regions. The authors point at the role of local and regional governments and institutions in development processes as well as the potential of local governance and soft institutions for promoting sustainable development.

The insights from this study have practical implications for policymakers and stakeholders in LAC cities. Our findings can inform urban planning strategies, waste management policies, and the development of inclusive CE initiatives that address the unique challenges of rapidly urbanizing areas in the region. By highlighting the importance of place-based approaches and the need for locally adapted CE frameworks, this research can guide decision-makers in creating more effective and contextually appropriate CE strategies.

The next section introduces the case studies, the UCAF, and the data collection and analysis. In Sect. 3, we present the findings from the application of the framework, based on insights from an extensive document analysis and expert interviews with representatives from each city. Next, Sect. 4 discusses the relevance of our findings, followed by concluding remarks in Sect. 5.

Materials and Methods

Case Study Description

Below, we briefly describe both cities and provide some socioeconomic data. We selected these case studies as both cities are currently implementing a CE strategy at the city level. They are also among the first signatories of the Circular Cities Declaration for LAC. Both cities are comparable in size and population density and present similar challenges, for instance, linked to the high informality in the waste sector (see Table 2). While these cases might not capture the depth of challenges for a CE transition in the region, the efforts of these early adopters of the CE might provide more in-depth insights into visions, strategies and stakeholders supporting the CE transition.

Bogotá, Colombia

Bogotá, the capital district of Colombia (in Spanish, *Distrito Capital, Bogotá D.C.*), is located in the country's geographic center, generating 20% of the national GDP [52]. Bogotá is home to 8 million citizens, or 15.2% of the national population [53]. The city's GHG emissions are 11 million tonnes of carbon dioxide equivalent (CO₂e). Almost half of the

Table 2 Country profiles for Colombia and Mexico (reference year 2019) and City data for Bogotá and Mexico City (reference year 2023)

Key figures	Colombia	Mexico
Government form	Unitary country	Federation
Area (km ²)	1,141,750	1,964,375
Population	48,911,000	125,772,000
Population density (inhabitants/ km ²)	45	66
GDP (USD billions)	786.8	2,671.9
GDP per capita (USD)	16,087	21,244
GDP growth rate %	3.3	-0.1
Unemployment rate %	14.3	4.4
Human Development Index (HDI)	0.767 (rank 83)	0.779 (rank 74)
Number of subnational governments: Municipal level	1,103	2,465
Number of subnational governments: Regional or state-level	33	32
Key figures	Bogotá	Mexico City
Population	8,380,801	9,209,944
Area (km ²)	1,623	1,485
Population density (inhabitants/ km ²)	4,764	6,202
Unemployment rate %	10.1	4.07
Informal labor rate %	42	46.5

Source: [53, 64–67]

city's emissions are generated from transportation (48%), followed by buildings (34%) and waste (18%) [54]. According to the city's Secretary of Environment [55], air quality has improved by 8% in recent years, with current levels of 18.10 fine particle air pollution (PM_{2.5}). However, these levels exceed air quality guidelines by the World Health Organization by at least three times, suggesting an annual mean concentration of PM_{2.5} should not exceed 5 µg/m³ [56].

In 2019, Colombia, as the first country in the region, introduced a National Circular Economy Strategy, with the ambition "to become a leader in the implementation of the CE in the region by 2030" ([57], p. 35). The strategy supports the National Green Growth Policy and its targets of increasing the national solid waste recycling and reuse rates by 17.0% and reducing greenhouse gases by 20% by 2030 [57]. Six material and energy flows are prioritized: (1) industrial materials and consumer products; (2) materials from packaging; (3) biomass; (4) energy flows; (5) water; and (6) construction materials. The national strategy also acknowledges the role of regions and cities as an engine to promote the CE, recognizing the allocation of resources, people, and infrastructure. At the same time, cities and regions present "opportunities for a transformation towards a circular economy and cultural change, through efficient commercial and industrial systems, selective waste collection, taxation of waste disposal in landfills in landfills, design of collective transport systems and use of treated wastewater, among others" ([57], p. 23). Based on the national ambitions, participants in our data collection reported that the city of Bogotá is currently developing a public policy on Sustainable Consumption and Production with a focus on the CE.

Mexico City, Mexico

Mexico City (in Spanish, *Ciudad de México*, CDMX) is one of the largest metropolitan cities in the world, with a population of about 9.2 million inhabitants [58]. According to Mexico City's Secretary of Environment (SEDEMA), the city emitted 22 million tonnes of CO_{2e} in 2018, with transportation accounting for about 72% of the city's total GHG [59]. Each citizen generates approximately 1.2 kg of solid waste daily, resulting in about 12,400 tonnes of solid waste collected and transported daily [60, 61]. Almost half of the waste (46,8%) is organic waste [60].

To our knowledge, there is no national CE policy. However, CDMX passed a Circular Economy Act in February 2023, with a focus on private sector engagement [62]. Additionally, the city's zero-waste action plan includes the recycling and recovery of waste for energy as strategies of the CE [63]. Table 2 provides country profiles for Colombia and Mexico with some key data for Bogota and Mexico City.

The Urban Circularity Assessment Framework (UCAF)

The UCAF was developed under a Vinnova-funded project, aimed at improving the CE at the city level. It entails five interconnected components (see Fig. 1), aiming to assist in discerning priority interventions [32]. The first component (1), the city's CE vision, aims at understanding the city's CE ambition, distinguishing between strong (society-wide) and weak (technology-driven) CE visions for instance [46]. Assessing the city's CE vision requires analysing the city's level of ambition, its drivers and understanding of the CE. Scholars highlight, for instance, how the principal aim of a CE transition has evolved from

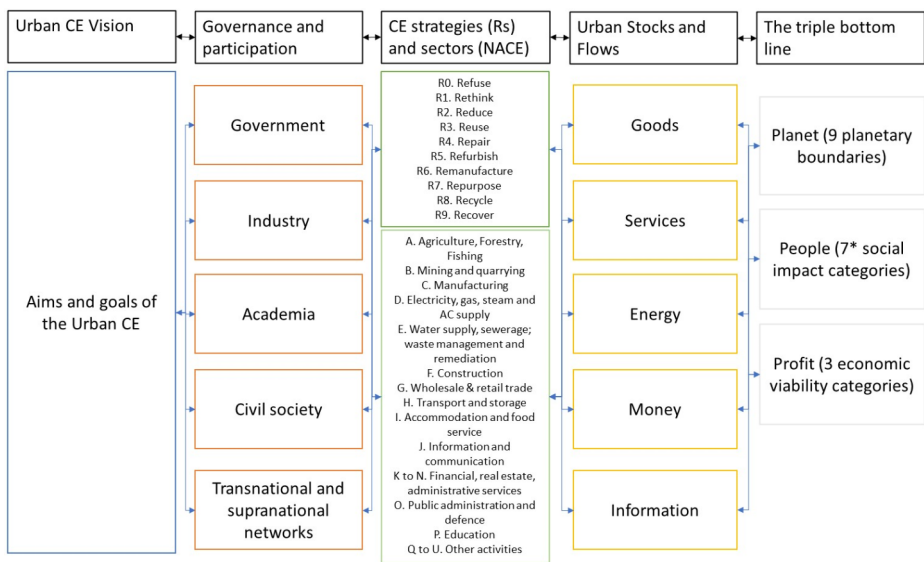


Fig. 1 Five interconnected UCAF components. Source: [32]

sustainable development towards more frequent mention of environmental quality, economic development and social equity to a lesser extent [68]. The second component (2) of the framework considers the institutional arrangements and the participation of different stakeholder groups organized along the quadruple helix model, including public and private sectors, academia, and civil society. Additionally, the framework considers the role of transnational and supranational organizations. It facilitates understanding the level of horizontal (e.g., across city departments and sectors) and vertical (e.g., bottom-up and top-down) integration of stakeholders within a city [69]. Scholars highlight that the inclusion or exclusion of specific stakeholders can present a determining factor for the success or failure of transitions [70, 71]. The third component (3) aims to understand which sectors and R-strategies are addressed in the CE strategies to achieve the city's CE vision. Assuming a comprehensive understanding of the CE concept, it stresses diverse sectors (based on the NACE classification system) and ten hierarchical R-strategies ranging from refusing consumption (R0) to recovery of waste and energy (R9) [72]. The fourth component (4) relates these strategies to the city's urban stocks and flows. It aims to showcase the policy and planning implications of the CE strategies. Lastly, the fifth component (5) addresses the impacts of the city's CE transition considering wider societal impacts, from a triple-bottom-line perspective, encompassing environmental, economic, and social impacts. The concept of planetary boundaries guides the assessment of environmental impacts [73], broadening its application at the city level [74]. Economic performance indicators related to GDP growth and innovation guide the understanding of economic impacts. Whereas the social impacts of a CE transition are less understood and studied [28, 75]. However, the framework utilizes eight categories developed by the International Association for Impact Assessment, broadening current perspectives [76].

To facilitate the assessment of a city's urban circularity approach, the framework suggests guiding questions and indicators under each component. Examples include: What are

the city's ambitions for the CE and why? (Component 1); Which organizations participate at which stage in the CE process? (Component 2); What sectors are covered by the CE strategy, and how representative are these sectors for the local context? (Component 3); What kind and type of stocks and flows are being considered and what type of data is being collected on them? (Component 4); Which impacts under each category of the triple bottom line have been considered? (Component 5). The collection of both qualitative and quantitative data is required to answer some of these questions and apply the framework to a specific city. Table 3 provides some examples of indicators to guide the assessment and a detailed outline is provided by Vanhuysse et al. [32].

Building on previous studies on indicator-based frameworks, we reflect on the reasoning of selecting the UCAF and assess the comprehensiveness and rigour of the framework based on pre-defined criteria. This approach aims to support the evaluation of its applicability to different geographic and socioeconomic contexts. Based on recommendations from literature on circularity metrics, Papageorgiou et al. [31] suggest eight criteria for the evaluation of indicator-based frameworks, including (1) transparency; (2) stakeholder engagement; (3) effective communication; (4) ability to track temporal changes; (5) applicability; (6) alignment with specific CE principles; (7) validity; and (8) relevance to sustainable development. For the assessment of the frameworks, they suggest whether a framework fulfills fully or partially each criterion. In Sect. 3, we provide an evaluation of the UCAF with suggestions, answering our second research question on the applicability of the UCAF.

Data Collection and Analysis

Following an explorative case study approach, we used a mixed methods approach and triangulated our data, combining document analysis and in-depth expert interviews for our data collection. We started by mapping the context of a CE transition in the region, reviewing scientific and non-scientific literature, and searching for initiatives in the region to iden-

Table 3 Indicators guiding the assessment of the UCAF

Component	Suggested indicators	Potential ranges
Vision	Number of actors supporting the city's CE vision Number of actors knowing about the city's CE vision	Weak (technology-driven) to strong (society-wide) CE vision taken in the city
Governance and participation	Number of actors involved in the design, implementation, monitoring, evaluation and learning processes Level of participation of different actors in these processes	Low to high involvement and level of participation of different stakeholders in the city's CE strategy
Circular strategies and sectors	Number of sectors considered under the city's CE strategies, presenting priority sectors Level of R-strategy in each sector	Low to high systematization and integration of CE strategies based on city priorities, including key sectors and R-strategies
Urban stocks and flows	Material flow data Number of CE initiatives in the city Number of information campaigns on CE	Low to wide range of socioeconomic and biophysical stocks and flows considered within a city
Societal consequences – the triple bottom line	Climate change-related data Number of jobs or quality of employment	Low to high considerations of the impacts of the city's strategies on planet, people, and profit

Source: Based on Vanhuysse et al. [32]

tify relevant actors, policies and programs that support a CE transition in the respective city. Then, we conducted interviews with key actors in the public sector in each city who are working towards the development and implementation of the city's CE strategy.

Table 4 contains the policies and programs supporting a CE transition in the respective cities and countries, and consequently, the 13 documents reviewed for our analysis. We identified the documents through governmental websites, expert recommendations, and snowballing techniques. Documents were selected based on their relevance to CE strategies and policies in each city and had to include an explicit mention of the “circular economy” concept, where the highest number reached 274 explicit references to the CE. The publications ranged from 2019 to 2023, illustrating the recent nature of CE initiatives in LAC cities. Our data collection was guided by a holistic understanding of the CE concept, based on the 9R framework, diverse sectors, and a range of governance levels to capture a comprehensive CE perspective [77]. We also consulted databases from international organizations and CE networks to capture collaborations with supra- and transnational organizations, including for instance, the “Urban Platform and Cities of Latin America and the Caribbean” working towards circularity [21], resources from Circle Economy [78], the Ellen MacArthur Foundation [79] and ICLEI [80]. The document analysis was done deductively and iteratively, using Microsoft Excel for coding, categorization and synthesis of key themes. The coding framework was based on the five components mentioned in Vanhuyse [32], as explained above. Annex 1: Table 7 contains further details on the coding framework.

During May – October 2023, we interviewed eight key experts from the public sector working with the CE strategies in key departments in each city (Annex 2: Table 8). These experts were chosen based on their direct involvement in CE policy development and implementation within key city departments. As the public sector was identified as the main driver of the city's CE strategy, representatives from different departments with diverse functions were interviewed. Our aim was two-fold: (1) to deepen our understanding of the city's CE plans, and (2) to validate our findings from the document analysis. The questions were structured around the elements in our framework (Annex 3: Table 9). The interviews

Table 4 Overview of reviewed documents

National policies towards a CE transition	
Colombia	Mexico
National CE Strategy, 2019	<i>National CE Roadmap, emerging</i>
Local policies and programs towards a CE transition	
Bogotá	Mexico City
<i>Public Policy for Sustainable Consumption and Production (with a focus on a CE), emerging.</i>	<i>CE Strategy, emerging.</i>
Climate Action Plan for Bogotá, 2020–2050	Climate Action Plan for Mexico City, 2021–2030
Green Growth Strategy for Bogotá, 2021–2030	Progress report on environmental and climate change program, 2018–2024
Circular Textiles Guide under initiative <i>Bogotá Circular</i> , 2020	Waste Management Plan for Mexico City, 2021–2025
Circular Business Guide, 2020	Waste management inventory for Mexico City, 2020
Territorial Planning Strategy 2022–2035	Zero-waste Plan for Mexico City, 2019
District Development Plan, 2020–2024	General Development Plan for Mexico City, 2020–2040

were semi-structured, allowing for a flexible structure and open-ended questions. In both cities, the respective Secretaries of Environment were the main public entity responsible for developing their city's CE strategy. In the case of Bogotá, the city's CE strategy was being developed also with the Secretary of Habitat and the Secretary for Economic Development, hence we interviewed CE experts in all three secretariats. The interviews with the four experts in Bogotá were conducted in person during a field visit in May 2023. To enhance our contextual understanding, we conducted informal site visits to waste management facilities in Bogotá. While these visits were not included in the formal analysis, they provided valuable insights into the informal waste sector and the challenges of formalization, enriching our overall understanding of CE implementation challenges in LAC cities. The interviews with the four representatives of Mexico City were conducted virtually. All interviews were conducted in Spanish and lasted for approximately one hour. We recorded and transcribed the interviews, sending a consent form in advance to all participants and assuring our interviewees' anonymity. We employed NVivo software for our qualitative data analysis, utilizing a combination of deductive and inductive coding approaches. The UCAF guided the analysis of the interviews. Emerging themes were identified inductively. This approach allowed us to identify additional insights, such as specific opportunities and obstacles in implementing each city's CE ambitions. Consequently, we were able to capture nuanced themes and insights related to the CE transition in both Bogotá and Mexico City.

Application of the UCAF for Bogotá and Mexico City

To answer our first research question (RQ1), we compare the CE approaches in Bogotá and Mexico City and outline our findings for both cities. Next, we examine our second research question (RQ2) through an evaluation of the UCAF, focusing on its applicability across different contexts and the lessons learned from its application in LAC.

How the CE is Viewed in Bogotá and Mexico City

Figures 2 and 3 visualize our findings on the CE approaches in Bogotá and Mexico City against the five components of the UCAF and their interconnections. It illustrates how the CE is viewed and governed, which strategies are emphasized, how urban stocks and flows are considered, and which potential societal impacts are addressed (from left to right). The first part of this section addresses the first sub-question, (RQ1.1) *What are the key priorities in each city, including CE strategies, sectors and main stakeholders?*

Bogotá's CE Approach

In assessing Bogotá's CE vision, we identify that its ambition is linked to the national CE plans as well as the city's green growth agenda (*Estrategia Distrital de Crecimiento Verde*) [81]. Colombia is the first country in the region that has implemented a national CE strategy and aims to become a "leader in the implementation of the CE in the LAC by 2030" ([57], p. 35). Aligned with the national CE strategy, the CE is described as a tool towards sustainable development in various public sector documents, particularly to tackle climate change and contribute to all three pillars of sustainable development.

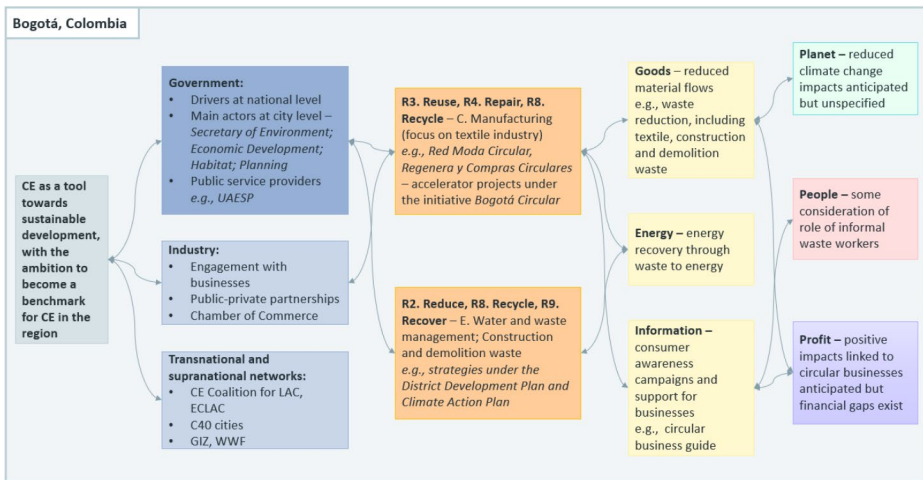


Fig. 2 Overview of Bogotá's CE approach mapped against the UCAF components, including from left to right: the CE vision, governance, strategies, stocks and flows, and anticipated impacts

Regarding the governance of the CE agenda in Bogotá, the public sector presents the main driver, comprising Bogotá's Secretary of Environment, as well as the Secretary of Habitat, and the Secretary of Economic Development. Other key public actors are public service providers in the city, such as the entity managing municipal waste (*Unidad Administrativa Especial de Servicios Públicos, UAESP*) and Bogotá's water and wastewater company (*Empresa de Acueducto y Alcantarillado de Bogotá, EAAB*). We have identified the private sector as the second most often prioritized stakeholder group. Engagement with academic institutions, including universities and research institutes has been emphasized by experts during our interviews, however, we identified no systematic approach to support the inclusion of academia in the city's CE ambitions. Similar findings were observed for civil society and citizens, where isolated initiatives such as awareness campaigns were noted by city representatives but no cohesive strategies for citizen and civil society engagement could be identified. The city is also participating in different trans- and supranational networks.

Bogotá's CE strategy prioritizes key main sectors: (1) waste and water, (2) textiles, and (3) construction and demolition waste. We find a concentration of strategies such as recycling and recovery, while more recent initiatives consider reusing and repairing, addressing linear consumption models. *Bogotá Circular* presents the most significant and recent CE initiative, aiming to integrate efforts from various sectors to accelerate the CE transition. It encompasses several accelerator projects, including initiatives for improved consumption and production processes in the textile sector, such as *Red Moda Circular*, and *Regenera y Compras Circulares*. Other city plans also emphasize the CE, notably, the fourth chapter of the District Development Plan for 2020–2024, which highlights CE for eco-efficiency, recycling, waste management, and inclusion of waste sector workers. The expert interviews reveal that the three primary city secretaries (Secretary of Environment, Habitat, and Economic Development) are developing a public policy for sustainable consumption and production. This policy aims to consolidate the city's various CE initiatives.

Mexico City’s CE Approach

Mexico City’s overall goal for 2050 is to reach resilient and carbon-neutral development, with economic growth that is based on the sustainable and efficient use of natural resources, a local and solidary CE, creating green jobs, innovation, and technology ([61], p. 15). It illustrates that the CE is considered more from a techno-economic perspective in city plans, nevertheless, city representatives have stressed the relevance for all three sustainable development pillars. In addition, the CE forms part of the city’s Zero Waste plan (*Basura Cero*), with the overall objective of strengthening the prevention, reduction, reuse, recycling and recovery of waste in the cross-cutting framework of the CE ([61], p. 85). It includes four action areas, (1) preventing waste generation and redesigning goods and services; (2) sustainable management of solid waste and construction waste; (3) harnessing the energy potential of waste; and (4) improving sustainable wastewater treatment ([61], p. 11). The local climate action plan states the following, “Mexico City is governed by the principles of the circular economy, waste is recognized as materials that function as inputs to other processes, and waste is reduced as much as possible” ([61], p. 85). Specific goals are stated, for instance, in the city’s progress report for climate change, “Our goal is to be a zero-waste city. By 2024 we will reduce the volume of waste going to landfills by 50 percent compared to 2018. In addition, we are increasing the level of recycling and composting, and we are fostering a circular economy”[82], p. 7).

The vision stated in different public sector documents highlights that waste management presents a major focus area concerning the city’s CE ambitions. However, during our expert interviews, it was stressed that the city aims to move beyond waste management and recycling. Therefore, a CE program is under development. It is presented as an instrument within the legal framework of the city’s CE plans, covering the following nine key areas: (1) responsible production and consumption; (2) adoption of service models; (3) supply chains;

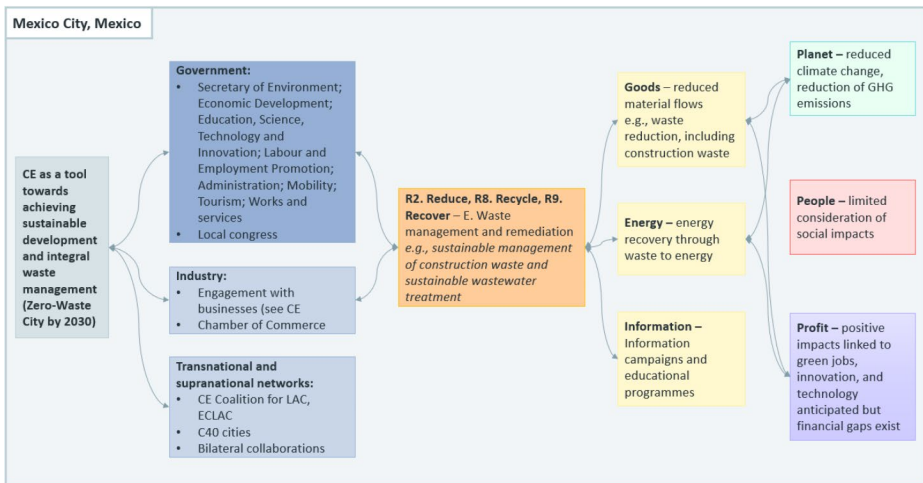


Fig. 3 Overview Mexico City’s CE approach mapped against the UCAF components, including from left to right: the CE vision, governance, strategies, stocks and flows, and anticipated impacts

(4) circular markets; (5) zero waste; (6) the right to repair; (7) efficient water use; (8) efficient energy use; and (9) a circularity culture. It aims at setting concrete actions towards the implementation of a CE in Mexico City. Notably, the city is at an early stage of its transition process and the interest to further explore circular business models and opportunities has been highlighted by the experts in Mexico City. Strategies implemented to date are linked to the city's zero-waste action plan towards a CE, focusing on reducing (R2), recycling (R8), and recovering (R9). Regarding the city's CE governance and participation, a wide set of public actors are driving the transition, with the Secretary of Environment as the main public actor but also including the Secretary of Education, Science, Technology and Innovation, implementing educational programs to drive the CE transition in the city. Other stakeholder groups do not have a significant role.

Our comparison of the approaches in both cities (Table 5) highlights gaps in three main themes linked to (1) the vision which shapes its prioritized CE strategies, (2) the engagement with city stakeholders, and (3) the consideration of different societal impacts.

(1) Narrow CE Vision and Consequently Strategies

Neither city presented a clearly formulated CE vision. Instead, CE is understood as a tool supporting other city ambitions such as sustainable development. In the case of Bogotá, the ambition of becoming a regional leader in the CE was expressed through the key expert interviews, while Mexico City's vision is driven by the city's goal of becoming a zero-waste

Table 5 Comparison of Bogotá's and Mexico City's CE approaches along the five UCAF components

Component	Bogotá	Mexico City
Vision	Broader urban CE vision but fragmented – focus on technological innovation; CE understanding based on conceptualisation by European stakeholders	Limited urban CE vision – focus on technological innovation; CE understanding based on conceptualisation by European stakeholders
Governance and participation	Few stakeholder groups involved – mainly public and private actors; collaboration across three city secretaries; wish for stronger collaboration with the private sector expressed; challenges in involving civil society	Low participation and integration of stakeholders – public sector as the main driver, but involvement of diverse city secretaries identified; attempts for stronger engagement with private sector limited
Circular strategies and sectors	Few R-strategies and sectors considered – <i>Bogota Circular</i> presents a first attempt to systematize CE initiatives for a broader vision, including, different sectors and higher ranked R-strategies; ambitions of targeting consumption-based approaches and broadening the city's CE strategy	Narrow strategies – starting from a waste perspective linked to the city's zero-waste target, resulting in few R-strategies and sectors
Urban stocks and flows	Little consideration due to lacking assessment of baseline data; challenges with data collection and harmonization	Little consideration due to lacking assessment of baseline data
Societal consequences – the triple bottom line	Limited consideration – driven mainly by environmental considerations and to some extent financial; first efforts to address challenges regarding the inclusion of waste pickers, however, lacking a systematic approach	Limited consideration – driven mainly by environmental considerations and to some extent financial; gaps in addressing social impacts

city. In both cities, the narrow view of the CE resulted in a focus on the waste management sector and consequently, lower R-strategies. Nevertheless, Bogotá presents a broader vision and includes other sectors, targeting construction and demolition waste as well as the textile industry.

Yet, both cities are at an early stage of their respective CE transition and are developing CE strategies. The CE vision, CE strategies and initiatives to advance the CE are scattered in diverse city plans, including climate action plans, local planning, and waste management programs (see Table 2). One key expert from Bogotá described the CE vision as “all over the place”. Another expert from Mexico City’s Environment Secretary highlights that “the topic of CE started with a focus on waste” and “when the CE boom started, people were believing that just with recycling you are already doing CE”. Regarding CE progress, an expert stated, “we as Mexico City still need more drive because I know that we could do more things in other sectors and areas, unlike now, where we are still taking small and slow steps”. An expert in Bogotá also stresses that the city “did not dare to quantify” the city’s goals with regards to a CE transition and that “they are a bit more qualitative”. It illustrates challenges in the formulation of a clear CE vision and strategies and actions linked to it. We identify a rather top-down planning of the cities’ CE ambitions, emerging from national and territorial plans and supported by the international actors, reflected in the supra- and transnational collaborations.

(2) Low Engagement with Different Stakeholders

In both cities, there is limited engagement with different stakeholders. Particularly, citizens and civil society participate rarely and are described as challenging to engage with in both cities. There are some attempts to raise awareness and build knowledge on the CE among citizens through information campaigns and virtual training in Bogotá and Mexico City. Even though the role of knowledge institutes and universities is recognized to support a CE transition, there is no formal involvement of academia. In Mexico City, challenges in the coordination of efforts across multiple city departments are present. While the Secretaries of Environment lead the CE ambitions in both cities, better integration with other secretaries is essential. There is a need to identify where the main responsibilities of key CE sectors lie within different public sector representatives. In addition, in both cities, informal waste sector workers should be more prominently involved given their substantial role in the collection and recycling of municipal solid waste. Major challenges were stressed, particularly by experts in Bogotá, around the formalisation of the waste sector and the integration of waste sector workers, spanning across sociopolitical and economic aspects, such as the vulnerability and exposure of waste pickers to precarious settings, and severe health impacts [83]. Historically, waste workers play a significant role in Bogotá’s waste management and are highly dependent on collecting and sorting waste materials as a source of income [84]. Bogotá is estimated to have over 25,000 waste workers, organized under approximately 238 waste recycling associations, who recycle around 18% of the city’s total of 1,600 tonnes of waste generated per day [85]. Immense efforts and investments are required around training, equipment, and addressing occupational health hazards for waste management and recycling [86].

(3) Lack of Social and Financial Considerations

Both cities currently mostly consider environmental gains related to reduced climate change impacts. Yet, while economic gains related to circular business models and green jobs are somewhat presented in both cities, there is no detail on the financial challenges of the CE transition in both cities. As one of the experts in Mexico City highlights, “the issue of financing is a complex issue that applies everywhere, but it is complicated to propose strategies and programs without having studies that allow you to know where you stand and where you want to go”. Challenges around attracting external investments for financing new technologies were expressed; in Bogotá, for example, a lack of investments into biodigesters for composting organic waste was emphasized. Considering that over 50% of the city’s total waste is organic, biodigesters present substantial potential [87].

Social impacts are the least considered, especially in the case of Mexico City. One expert from the city commented “no, in fact, I think that it is missing. We see the social focus as implicit, where we know that it will have a benefit for society, for example, that it can generate jobs, and can be used as a tool for the creation of new jobs”. This observation echoes what scholars have pointed to as well: the CE concept mostly stresses environmental and economic gains, with social equity covered to a lesser degree [68]. For instance, the promise of job creation is not well studied across the globe, even to a lesser degree in economies with high informality rates and other development challenges [10]. In these economies, the role of informal waste workers is often not acknowledged [83]. In the case of Bogotá, informal sector workers, locally known as *recicladores*, play a crucial role in the city’s waste management system and emerging CE strategy. The formalisation of the waste sector is discussed in strategic city documents and described as one major obstacle by the key public actors in the interviews. Considering the contribution of waste pickers, from collecting, sorting, and selling recyclable materials, Bogota’s CE initiative could leverage their expertise to increase the legitimacy and effectiveness of strategies [88–90]. Hence, a better understanding of the positive and negative impacts linked to the city’s ambition to formalise the waste sector will be imperative.

Evaluation of the UCAF

The framework applies to different contexts, with some weaknesses. Table 6 provides an evaluation of the framework against different criteria for assessing indicator-based frameworks [31]. Below we provide further details on each criterion and to which degree the UCAF fulfils these, with further suggestions for improvement.

Criterion 1 refers to the transparent description of the methodology, allowing for replication and reliability, while criterion 2 assesses to which extent stakeholders were engaged through participatory approaches in the development. The steps for developing the UCAF include different participatory elements, ranging from workshops to conferences, and are described in the methods and materials section of the UCAF [32]. However, we note that civil society did not form part of the multi-stakeholder consultations. Criterion 3 refers to the extent to which the results are effectively communicated, for instance, if illustration techniques are applied. The UCAF supports the illustration of findings, but we note that guidance on how to visualise quantitative indicators (e.g. in the form of a Sankey dia-

Table 6 Evaluation of the UCAF based on assessment criteria for indicator-based frameworks

Criteria	Fulfilled by UCAF	Rationale	Suggestion for improvement
1. Transparency	Yes	The UCAF entails a detailed description of materials and methods	Include different versions of the framework to understand the whole process
2. Stakeholder engagement	Yes	Multiple participatory processes, including workshops with public and private sector as well as academia, conferences, and other consultations	Include civil society into the process of co-designing the framework
3. Effective communication	Yes	Illustration to present findings suggested, highlighting the CE focus of a city and indicating gaps	Guidance on how to incorporate qualitative and quantitative indicators, and how to illustrate changes in the CE progress and compare cities
4. Ability to track temporal changes	No	No metrics identified that indicate temporal changes, results can be rather seen as a snapshot of a city's CE transition	Classify a city's CE transition progress, e.g., from early implementer to pioneer and add metrics that illustrate temporal changes
5. Applicability	Partial	Limitations linked to data accessibility	Suggest a method to either down-scale national data or how to access relevant data
6. Alignment with specific CE principles	Yes	CE understanding based on 9R-framework	Prioritize different R-strategies clearer and specify which sectors might be more relevant for a CE transition
7. Validity	Partial	Difficult to see progress towards specific CE goals	Emphasize contextual indicators
8. Relevance to sustainable development	Yes	Holistic perspective, stressed by triple bottom line component	Support the assessment of impacts and reflect on trade-offs

gram) could be provided as well as some type of scoring system for comparing cities' urban circularity assessments. Criterion 4 reflects on whether the framework considers temporal changes, including metrics to monitor progress towards a CE and determine the degree to which goals and targets are achieved over time. To our knowledge, the UCAF does not include metrics that indicate temporal changes. Regarding criterion 5, the applicability of a framework based on available, accessible, and regularly updated data, which allows for replication in other contexts, we note that the UCAF partially fulfils this criterion. Some indicators suggested by the UCAF, for instance, for assessing the different impacts, are difficult to quantify, especially in the context of a city, and further guidance is required. For criterion 6, the alignment with specific CE principles, we find that the UCAF was developed considering the 9R-framework [91], presenting a nuanced CE understanding. We note that a broad set of sectors is considered [92], but it might be useful to highlight sectors with a greater CE potential. Criterion 7 entails 12 validity indicators as discussed in other studies on CE principles [93, 94]. Even though the UCAF considers various validity indicators, it lacks consideration of contextual indicators and presents challenges in reflecting on changes connected to CE interventions. Lastly, evaluating criterion 8 on the relevance to sustainable development, we note that the UCAF considers various sustainable development pillars. As an addition, potential trade-offs between different goals could be taken into consideration.

Discussion

This section synthesizes our findings from the application of the UCAF in Bogotá and Mexico City, addressing our primary research questions. We identify common challenges for the implementation of CE strategies in both cities. We discuss lessons that can be derived from the application of the UCAF and suggest areas that need further attention for supporting the CE transition in both cities.

Systems Thinking and Place-based Sensitivity to Support Inclusive CE Transitions in LAC

Our application of the UCAF in both cities highlights the need for systems thinking and place-based sensitivity in supporting inclusive CE transitions in LAC cities, as stressed by the findings of our first research question (RQ1).

The CE concept has gained traction as a potential pathway to sustainable, just and resilient urban futures. However, Calisto Friant et al. [46] highlight that the definition, objectives and implementation of CE remain ambiguous, with diverse interests and actors involved. Further, they emphasize the lack of holistic CE approaches, noting a predominant focus on positive technocratic perspectives, while neglecting the complex and pluralistic nature of the CE and its evolution. Iacovidou et al. [95] argue that transformational change needs to go beyond closing materials, components and product loops. They propose a systems approach encompassing five interconnected sub-systems: resource flows and provisioning services; governance, regulatory frameworks and political landscapes; business activities and the markets; infrastructure and innovation; and user practices. This approach acknowledges the dependence on cultural, spatial, and temporal characteristics.

For our two case studies, we found a scattered CE vision, and an understanding of the CE concept that is shaped by actors in the Global North, allowing for little attention to the local context and its complexities. It leaves uncertainties around considerations of place-based sensitivity and territorial cohesion [47, 48, 50]. As noted by Paiho et al. [30], cities need to start with the formulation of a clear vision that is shared by all stakeholders to support the implementation of CE strategies. We note similar challenges as found for European cities, where narrow CE visions lead to limited R-strategies and sectors, with little consideration for social impacts of a CE transition in cities [32]. LAC cities encounter similar challenges. Our analysis revealed specific gaps in Bogotá's and Mexico City's CE approaches, including challenges in stakeholder engagement, particularly with informal sector workers, and limited policy coordination across government levels.

Scholars have highlighted the need for combining technocratic and human-centered approaches [22], with the CE discourse being criticized for a lack of consideration of social and justice aspects [11]. Both countries are shaped by regional inequalities, for instance, about access to basic public services and transportation but also varying institutional capacities among sub-national governments [96, 97]. In this context, scholars have suggested an "amended framework" for the CE in the Global South, stressing an approach that considers the ecological economy and the social solidarity economy, thereby expanding the social and political aspects of the CE concept [88]. The CE can only be transformative and serve as a tool to address poverty and inequality in the region when implemented appropriately

and considering its human development [8]. As noted also by Vanhuysse et al. [28, 75] there are few considerations of social impacts linked to CE transitions in cities and when social impacts are considered they are perceived rather positively and are limited to a few aspects such as job creation.

The informal sector plays an essential role in the waste management and recycling in LAC. A more structural and inclusive approach is needed towards understanding the working conditions and ensuring the participation of waste sector workers. Burneo et al. [41] stress the benefits of the inclusion of waste pickers in the formalisation process and the application of CE strategies in the waste sector. Schroeder et al. [18] note that greater efforts from public and private sectors are required to make the informal recycling system more efficient in developing countries, along with technology transfer and creating decent jobs. In this context, Bogotá's experience with integrating informal waste pickers into formal recycling programs could inform Mexico City's approach to addressing informality in its CE strategy. Such knowledge sharing could be crucial for scaling up successful aspects of CE initiatives to national or regional levels.

We argue that the social implications need substantially more consideration, designing CE strategies for LAC cities focusing on the participation of informal waste workers and organizations as well as civil society, particularly if the city's focus is restricted to waste management. To facilitate this, policymakers should consider developing national CE frameworks that guide while allowing for local adaptations, establishing regional knowledge-sharing platforms, creating financial incentives for CE adoption, and investing in education and capacity building to enhance the development of skills and training for CE transitions [7, 98].

Lessons from the UCAF Application

The absence of comprehensive guidelines for designing, monitoring, and evaluating CE strategies in urban contexts impedes the implementation of effective strategies and hinders learning processes. To address this gap, we applied the UCAF, a novel framework for supporting CE transitions at the city level, to two LAC cities. We evaluated the UCAF using eight criteria for assessing indicator-based frameworks [31], aiming to identify strengths and weaknesses and determine its potential to further facilitate CE transitions in urban areas. We discuss the lessons derived from applying the UCAF to our case studies, supported by the findings of our second research question (RQ2).

First, the UCAF demonstrates limited consideration of contextual factors crucial for place-based policy approaches [47, 48]. Our analysis revealed that social, cultural, and institutional characteristics significantly influence CE transitions in Bogotá and Mexico City. For instance, insufficient public awareness and knowledge of circularity principles impede household waste separation practices. Moreover, the complex socio-economic and political landscape of LAC cities, particularly concerning the informal waste sector, presents unique challenges. Expert interviews highlighted tensions between waste picker organizations and the waste industry, underscoring the vulnerability of informal workers. While the UCAF provides general guidance for CE strategy implementation, it falls short in capturing the nuanced complexity of local contexts, a critical aspect of effective policy design in LAC.

Second, the framework could more explicitly delineate the drivers of CE transitions, facilitating the classification of urban CE visions and motivations across stakeholders. Scholars studying the drivers of CE transitions have categorised these drivers into environmental protection, societal benefits, and improved product development, with job creation, climate change, and waste management policy compliance emerging as primary motives [99]. In cities like our two case studies, where motives and CE responsibilities are dispersed, better integration between vision (Component 1) and governance (Component 2) is required. We propose that these cities initiate their CE transition by focusing on the governance and participation components of the UCAF, to identify key actors and develop a shared vision. This approach could foster more inclusive CE strategies, addressing the bureaucratic obstacles, lack of shared understanding, and misalignment between local and national efforts. In Bogotá, the CE ambitions are clearly linked to the national efforts of implementing the country's CE strategy, while experts in Mexico City highlight that developing a national CE strategy could accelerate local ambitions. Both cities base their CE understanding on the definition by the Ellen MacArthur Foundation and engage with trans- and supranational actors, illustrating that their CE ambitions are also driven by international actors. It would be useful to further understand to what degree these actors are driving the cities' CE agendas and if regional priorities are considered, as place-based CE strategies would suggest.

Third, the UCAF would benefit from incorporating a temporal dimension to account for different stages of urban CE transitions. This addition would enhance its utility in classifying city-specific CE trajectories and facilitate inter-city comparisons. Given that Bogotá and Mexico City are in the early stages of their CE transitions, applying all elements of the current framework proved challenging. The predominance of qualitative variables in our analysis reflects both the framework's limitations and the difficulties in collecting quantitative baseline data at the city level, particularly in developing countries' contexts. We recommend that these cities prioritize baseline data collection to establish clear links between their CE ambitions and local priorities before formulating a comprehensive CE vision and strategies. Furthermore, the UCAF could be enhanced by integrating methods for assessing urban material and energy flows and providing guidance for measuring environmental, social, and economic impacts through combined life-cycle assessments [100]. While it emphasizes the triple bottom line under the fifth component, it could be improved by incorporating social impact assessments within the urban flows and stocks component. Currently, the framework's indicators primarily support environmental metrics, with economic and social aspects having comparatively less consideration.

Limitations and Future Directions

While this study provides valuable insights into CE initiatives in Bogotá and Mexico City, several limitations should be acknowledged. The geographical scope of this research is confined to two major urban centers in LAC. While these cities are significant in terms of population, economic activities, and clearly stated CE ambitions, they may not fully represent the diverse urban landscape across the LAC region. Future research could expand this analysis to include a broader range of cities, encompassing different sizes, economic structures, and governance models to provide a more comprehensive understanding of CE implementation in LAC urban areas. Especially for LAC, scholars acknowledge the variety of urban typolo-

gies and diverse patterns of urban configuration [101]. The rapid expansion of urban and peri-urban areas and associated informal settlements pose one of the specific challenges to the region [102].

Another challenge relates to data availability and quality, particularly regarding quantitative metrics for CE assessing the urban stocks and flows, the framework's fourth component. The lack of standardized indicators and consistent reporting mechanisms across cities underscores the need for improved data collection and harmonization of CE metrics at the urban level [103]. Moreover, while our stakeholder interviews provided valuable insights, the sample was limited in size and primarily focused on public sector representatives. Future studies could benefit from a broader set of stakeholders, including the private sector and civil organizations as relevant stakeholders to a CE transition in the region. Lastly, the temporal scope of this study was limited to current and near-term CE initiatives. Given the dynamic nature of urban environments and the evolving concept of CE, longitudinal studies could offer valuable insights into the long-term impacts and evolution of CE strategies in LAC cities. Such research could help identify key factors contributing to the success or failure of CE initiatives over time. Despite these limitations, this study contributes to the growing body of knowledge on urban CE implementation in the LAC context and provides a foundation for future research in this critical area.

Conclusion

To our knowledge, this study presents one of the first comparative analyses of CE ambitions in LAC cities through a holistic lens, testing a novel framework and demonstrating its application in diverse contexts. Our research contributes both theoretically and practically to the field: (1) addressing the gap in the scientific literature for CE transition processes in LAC cities, while also (2) exploring potential implications of current CE strategies for local policymakers and various urban stakeholders.

The application of the UCAF, comparing the CE ambitions in Bogotá and Mexico City, revealed that both cities adopt technocratic CE approaches, focusing on lower R-strategies and limited sectors, primarily waste and recycling. We identified low engagement with diverse stakeholders in creating and implementing the cities' CE visions, with dominant involvement of the public sector. Both cities demonstrate limited attention to CE impacts, particularly in understanding economic and social implications, and face challenges in finance and investment.

However, it is noteworthy that both cities are in the early stages of their CE transitions and express ambitions to expand the scope of their CE strategies. Opportunities exist in addressing organic waste composition, investing in new technologies and increasing CE awareness through educational campaigns, targeting citizens, particularly children, to support shifts in mindsets and behaviors.

Our evaluation of the UCAF's applicability to different contexts revealed limited consideration of contextual factors. We argue that social, cultural, and institutional characteristics need greater emphasis to support CE transitions in LAC cities effectively. This finding underscores the importance of developing place-sensitive frameworks for CE implementation in diverse urban contexts.

Based on our findings we recommend adopting a systems perspective and supporting place-based approaches towards urban circularity with a regional lens. For LAC cities, understanding financial and socioeconomic implications, scaling current CE initiatives, and ensuring inclusive CE strategies are crucial. We propose a stepwise approach to support the implementation of inclusive CE strategies: (1) mapping power relations in the city (e.g., who is invited and heard); (2) collecting baseline data (e.g., what type of data is available and how regional priorities are reflected); (3) conducting stakeholder consultations on the CE strategy content and design; and (4) providing policy analysis (e.g., including social and financial implications).

Our study aligns with other scholars' observations that CE transitions in the region are at an early stage, indicating a need for further research. Future studies should explore the alignment of city approaches with national CE ambitions and develop baseline assessments of current material and energy flows to understand opportunities and potential trade-offs. Cross-country comparisons of cities of different sizes, particularly mid-sized cities experiencing rapid growth in the region, could provide valuable insights. Additionally, we emphasize the importance of understanding both the intended and unintended consequences of CE transitions and their impacts on different stakeholder groups, including vulnerable populations.

In conclusion, this study contributes significantly to CE research by highlighting the importance of place-sensitive frameworks and inclusivity in LAC cities. It provides a foundation for future studies on urban CE transitions in the region and offers practical insights for policymakers and stakeholders engaged in developing and implementing CE strategies in diverse urban contexts.

Appendix

Table 7 Codebook for the analysis of city documents and expert interviews

Circle	Category	Code
Vision and goals	Holistic	1 = Yes; 0 = No
	CE embedded with other targets and goals	1 = Yes; 0 = No
	CE stated as a means to an end	1 = Yes; 0 = No
	CE explicitly mentioned	1 = Yes; 0 = No
	Counts of "circular economy" or "economía circular"	<i>Number of counts</i>
Strategies	R-strategy ^a	1 = Yes; 0 = No R0. Refuse R1. Rethink R2. Reduce R3. Reuse R4. Repair R5. Refurbish R6. Remanufacture R7. Repurpose R8. Recycle R9. Recover

Table 7 (continued)

Circle	Category	Code
Governance	Sectors prioritised	1 = Yes; 0 = No A. Agriculture, Forestry, Fishing B. Mining and quarrying C. Manufacturing D. Electricity, gas, steam and AC supply E. Water supply, sewerage; waste management and remediation F. Construction G. Wholesale and retail trade H. Transport and storage I. Accommodation and food service J. Information and communication K to N. Financial, real estate, administrative services O. Public administration and defence P. Education Q to U. Other activities
	Evaluation mechanisms in place	1 = Yes; 0 = No
	City departments	1 = Yes; 0 = No G0. Link to other levels of governance G1. Environment department G2. Economic development and cooperation department G3. Dedicated circular economy structure G3. Urban planning and sustainability department G4. Waste management utility company or agency G5. City council/ municipal central administration G6. Innovation offices G7. Planning offices G8. Culture and education department G9. Transport department G10. Transnational and supranational networks G11. Private sector and businesses G12. Knowledge and research institutes G13. Citizens and civil society organisations
Link to stocks and flows	Industry	1 = Yes; 0 = No
	Academia	1 = Yes; 0 = No
	Civil society	1 = Yes; 0 = No
	Goods (materials, products, food, water and waste)	1 = Yes; 0 = No
	Services (transportation)	1 = Yes; 0 = No
Link to triple bottom line	Energy	1 = Yes; 0 = No
	Money	1 = Yes; 0 = No
	Information	1 = Yes; 0 = No
	Planet (9 planetary boundaries)	1 = Yes; 0 = No
	People (7 social impact categories)	1 = Yes; 0 = No
	Profit (3 economic viability categories)	1 = Yes; 0 = No

The categories were developed based on [32, 72, 74–76, 91, 92, 98].

^aEquivalent terms in Spanish that we searched for: Refuse= rechazar; rethink= repensar; reduce= reducir; reuse= reusar; repair= reparar; refurbish= restaurar; remanufacture= remanufacturar; repurpose= reutilizar; recycle= reciclar; recover= recuperar

Table 8 Overview of conducted expert interviews (anonymous)

Case study	City department, role	Date
Bogotá, Colombia	Secretary for Economic Development, technical advisor – responsible for CE implementation	16.05.2023
Bogotá, Colombia	Secretary of Environment, leadership role – responsible for steering CE strategies	17.05.2023
Bogotá, Colombia	Secretary of Habitat, technical advisor – responsible for waste management and CE	17.05.2023
Bogotá, Colombia	Secretary of Habitat, technical advisor – responsible for waste management and CE	17.05.2023
Mexico City, Mexico	Secretary of Environment, technical advisor – responsible for waste management	21.09.2023
Mexico City, Mexico	Secretary of Environment, leadership role – responsible for steering CE strategies	03.10.2023
Mexico City, Mexico	Secretary of Environment, technical staff – responsible for CE implementation	03.10.2023
Mexico City, Mexico	Secretary of Environment, technical staff – responsible for CE implementation	03.10.2023

Table 9 Interview guide**1. Introduction**

1.1. Can you introduce yourself shortly, which area you work in, and how you are involved with the topic of circular economy (CE) in your city?

1.2. What is your understanding of a CE, can you name a few keywords you associate with the concept?

2. Urban CE vision

2.1. Can you describe how your work with the city's CE strategy has started? When did it start, who initiated the CE plans and what was the motivation?

2.2. What is your city's ambition with regard to the CE? For instance, what is the overall vision and goal?

2.3. Are there local policies in place that support that ambition?

2.4. Is the CE integrated into other city plans? If yes, which ones and how?

3. CE strategies and initiatives

3.1. What strategies and initiatives have been implemented or are being planned to support the CE vision in your city?

3.2. What sectors are you mainly focussing on to promote the CE in your city?

3.3. What are some specific areas you would like to focus more on with regard to the CE plans? What could be the gaps?

4. Governance and participation

4.1. Which actors do you consider key to the successful implementation of the CE in your city?

4.2. Which actors have been involved in the development of the CE strategies in your city? What are the reasons behind their involvement?

4.3. How would you describe the level of involvement of these actors in the CE plans? For example, at what point in time, in what way, and to what extent were different actors involved?

4.4. Are there other actors who could contribute to the integration of the CE in your city but have not yet done so?

4.5. Is your city part of any CE network?

5. Opportunities and barriers

5.1. What do you consider the main opportunities for a transition towards the CE in your city?

5.2. Have you identified obstacles to the implementation of CE strategies in your city? If yes, what are these obstacles?

5.3. Which measures would you consider most relevant to overcome these challenges and advance the transition towards a CE in your city?

6. Concluding remarks

6.1. Do you have recommendations of other experts we could interview?

6.2. Could you recommend policy and strategy documents that might be relevant to our research on the CE in your city?

6.3. Do you have any other comments you would like to share or anything else you would like to add?

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Declarations

Competing Interests On behalf of all authors, the corresponding author states that there is no conflict of interest.

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