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Review

Circular Economy Transition on the Debate: Big Dreams but Harsh Realities

Florin-Constantin Mihai[1*]

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Abstract

This paper aims to reveal some discrepancies in scientific discourse related to the circular economy subtopics and to recognize some of the current and relevant shortcomings in an antagonism approach that requires more attention from scientists, policymakers, and civil organizations to reach a cohesion level between downstream and upstream measures of circular economy initiatives. These subtopics refer to the lack of basic waste management services and sanitation around the world; circular ambitions on "papers" and massive pollution in open environments; recycling and resource recovery between formal; informal, and criminal organizations; progress towards a circular economy transition and deficient waste-related statistics; Plastics Treaty between high and less ambitious countries; circular business models and greenwashing risks; smart cities and neglected rural communities. These subtopics are interlinked for circular economy discourse from local to global levels while this literature review paper reveals some pathways to overcome such societal discrepancies that act as an impediment towards a functional global circular economy.

Keywords: Circular Economy · Pollution · Environment · Zero-waste

1. INTRODUCTION

The circular economy (CE) topic gained momentum in the last years with a multitude of definitions and theoretical approaches that reveal the complexity of our current economies with related societal and environmental challenges (Kirchherr et al., 2017; Grafström & Aasma, 2021). The latest circularity gap report reveals that the use of secondary materials in the global economy decreased to 7.2% in 2023 compared to 9.1 % in 2018 (Circle Economy, 2023), despite the scientific and public discussions around the circular economy framework (Gallego-Schmid et al., 2024). Linear economy prevalence in current economic systems leads to resource depletion feeding the triple-planetary crisis such as climate change, biodiversity loss, and pollution while increasing geographical and socio-economic inequalities around the world. Waste diversion from landfills and waste to energy facilities is required from both environmental and public health perspectives (Rogers et al., 2024) and to adopt the zero-waste hierarchy principles with a focus on the upstream sector (ZWIA, nd) while providing sound waste management, sanitation, and wastewater services for all (Sankara Narayan et al. 2024). The circular economy mechanisms are multi-sectoral and interlinked with SDGs (Schröder & Barrie, 2024), but have some societal challenges and theoretical disagreements on their own (Corvellec et al., 2022). Social inequality such as gender bias needs to be addressed in future job-related markets (WRAP, 2023; Palm, 2024) besides the inclusion of vulnerable communities and individuals (e.g. waste pickers) to circular economy plans and highlighting their key role in some geographies in diverting resources into local economies from landfills and open environments while urgent financial support is required for low-income countries in waste-related projects (Lerpiniere, et al., 2025). A strong collaboration between municipalities and business actors with community participation is required to make the transition possible towards a functional

[1] Department of Exact Sciences and Natural Sciences, Institute of Interdisciplinary Research, "Alexandru Ioan Cuza" University of Iasi, 700506, Iasi, Romania;
[*] Corresponding author: mihai.florinconstantin@gmail.com

circular economy while international collaboration is crucial in tackling the secondary resources trades under legal terms ending the illicit channels (Europol, 2022) and reducing the geographical injustices (Vaz et al., 2017).

This paper aims to reveal some discrepancies in scientific discourse related to the several circular economy subtopics recognizing current and relevant shortcomings in the global CE transition.

2. LITERATURE REVIEW

This paper is a narrative literature review aiming to raise attention to critical subtopics in our global society relevant to CE transition discourse (see Figure 1). The antagonism approach refers to the analysis of the contrasting aspects of these subtopics such as lack of basic waste management and sanitation services while upstream innovation is a core principle of CE; circular ambitions on "papers" and massive pollution in open environments; recycling and resource recovery between formal, informal, and criminal organizations; progress towards a circular economy transition and deficient waste-related statistics; Plastics Treaty between high and less ambitious countries; circular business models and greenwashing risks, smart cities and neglected rural communities. This literature review argues such discrepancies and associated risks need to be managed to reach a cohesion level between upstream (e.g. circular product design, reuse, refill, repair, remanufacture systems) and downstream strategies (e.g. sanitation, waste management) that allow a solid pathway toward a functional global CE. Therefore, the cycle of the product must be accounted for from resource extraction, redesign, production, and use (upstream sector) to end-of-life management and sound disposal of waste as the last option (downstream sector) in line with the zero-waste hierarchy principles (ZWIA, n.d.).

The literature review analysis is based on peer-reviewed publications related to these seven contrasting subtopics combined with relevant reports of businesses, civil organizations, practical guides, open letters, and mass-media articles since these circular economy topics involve diverse stakeholders and require community support to address future policies in the CE framework. This paper is not a systematic review and is not intended to examine CE concepts as a theoretical battleground (Kirchherr et al., 2017; Corvellec et al., 2022; Eickhoff, 2024), but to provide a new perspective using multiple literature resources (academic, business, NGO's) through a contrasting analysis of these key seven subtopics with relevant implications to CE transition in a multi-level context and diverse geographies (sections 3-9). The paper points out the shortcomings and the risks associated with higher or lesser ambitions regarding policies, data gaps, legislation enforcement, and action measures required to provide multi-scale and multi-sectoral solutions as shown in Figure 1.

Specific risks identified for higher ambitions targets that focus on the upstream sector (e.g. product design, production, extended life of products in use) as a key circular economy transition route are: greenwashing, waste trades, criminal organizations and rebound effects. For the less ambitious targets, where downstream policies are prevalent (e.g. waste-sanitation-water management infrastructures), the main risks are related to vulnerable communities, pollution hotspots, social inequalities, and environmental injustice.

However, this work argues some pathways to mitigate such societal discrepancies and risks that act as an impediment to functional global circular economy transition even in less developed regions and/or most vulnerable communities through support of adequate legislation (e.g. single-use ban), community-based and decentralized solutions while digitalization, standardization, and new technologies could scale up the best initiatives related to the upstream sector in line with waste prevention and extended producer responsibility (EPR) principles.

Despite the higher or less ambitious routes, both upstream and downstream scalable actions are required to achieve a CE transition and to provide cohesion actions at national levels, but the related risks could act as an impediment to this process. Future research is required to improve data and reduce the current knowledge gaps in multi-sectoral scopes (academic, business, decision-makers, civil society) to better manage the existing inequalities and discrepancies.

Therefore, mitigation strategies of both centralized and decentralized systems are necessary to integrate both developed and less developed regions in CE transition efforts otherwise the CE transition will remain just a desirable objective in the theoretical framework without widespread geographical coverage and with an overall risk of failing to provide a systemic change (Eickhoff, 2024).

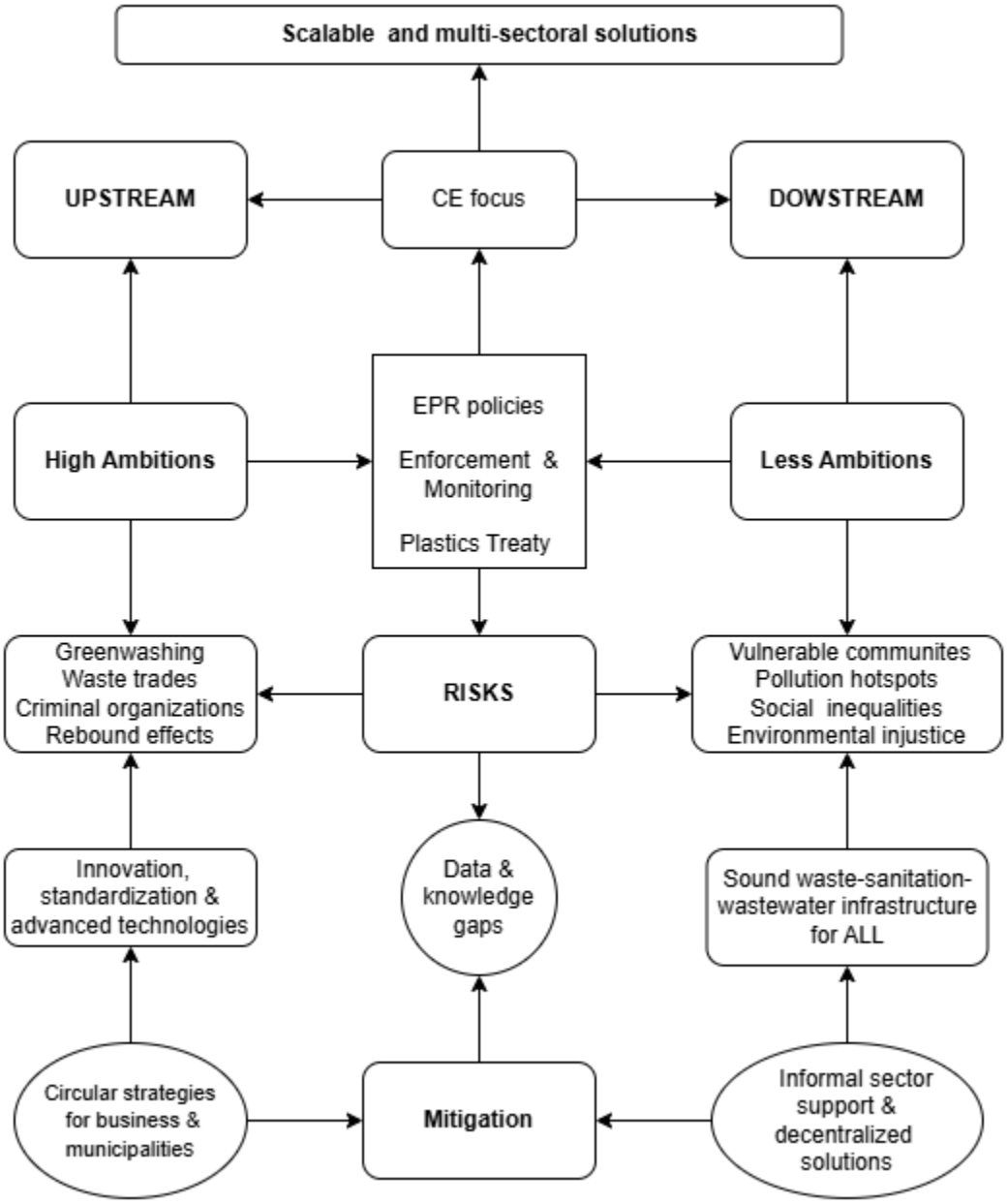

Figure 1. Shortcomings and Risks Related to Upstream and Downstream Strategies in Transition Efforts Toward a Circular Economy System. Source: Author

3. BASIC SANITATION AND WASTE MANAGEMENT SERVICES ARE STILL LACKING AROUND THE WORLD

The linear economy model is based on the "take-make-dispose model" and is fed by consumerism behavior "thrown away culture" generating higher amounts of waste around the world (UNEP, 2024). Packaging products or electronic devices are now more accessible than ever even for populations in remote regions.

The retail sector and sachet economies flooded local markets with single-use plastic items that ended up in open environments around the globe alongside ultra-processed food problems and related plastic packaging in developed regions (Yates et al., 2024). Circular design and waste prevention from the production stage (post-industrial and pre-consumer) with research, innovation, and technological support will play a key role in higher ambitions in CE terms as pointed out in Figure 1. CE focus on upstream policies is desirable (e.g. targeting plastic pollution, fashion

industries, and food waste prevention), but this approach must take into consideration other factors such as socio-economic conditions, technical capabilities, culture norms, and citizen behavior (Mihai et al., 2024a).

In contrast, some regions still lack basic waste collection services, wastewater, or sanitation facilities around the world (e.g. Africa, and Asia) causing waste and chemical pollution in surroundings and raising public health concerns. There is a great divide between urban and rural areas, particularly in low economies where only 2 % of households received regular waste collection services compared to 39 % in urban areas (World Risk Poll, 2024) while at the global level, 1.9 billion people lack waste collection services in rural areas (Mihai, 2017). Recent estimates reveal that around 2.7 billion people lack waste collection services at the global level (Wilson, 2023) however, a clear figure is difficult to obtain due to the waste statistics limitations. Peri-urban areas, urban slums, and rural communities remain exposed areas to uncontrolled waste disposal practices without proper funding to achieve at least a basic level of waste collection service (Whiteman et al., 2025). On this background, the uncollected waste flows from terrestrial environments reach freshwater bodies and further to marine environments via river networks (Gómez-Sanabria & Lindl, 2024). Universal access to sanitation services requires the development of a decentralized system for slum areas and remote regions where vulnerable communities are exposed to health threats (WeAreWater Foundation, 2022) similar to drinking water supply infrastructures (Pain, n.d). The circular economy discussion seems to be irrelevant so far in these regions where such critical sanitation and waste management services are not provided particularly for non-organic waste streams and uncontrolled waste disposal practices are prevalent. Some of the biowaste stream (food waste, green waste) could be used as animal feed or home composting without the necessity of a formal waste collection as part of self-management practices, but open burning of agricultural wastes is a “traditional” practice among rural communities and mixing with other waste streams is common nowadays (e.g. plastics) polluting the environment (Mihai et al., 2024a). In high-income economies, there are food wastage problems while underdeveloped regions are still facing famine as repercussions of climate change effects, conflicts (Tchonkouang et al., 2023), but food scarcity is a social threat to low-income communities of each country and better food waste and redistribution policies is required (Gonzalez et al., 2024). At the global level, the geographical inequalities are staggering despite the policy ambitions of SDGs in reducing some critical issues by 2030 (open defecation, famine, extreme poverty, improper water drinking facilities) that confirm their status as the most vulnerable communities to pollution including waste leakages (Mihai, 2017). Urbanization and rural-urban migration led to informal settlement development with precarious conditions that feed public health threats related to poor sanitation and waste management facilities (Mihai 2017; WeAreWater Foundation, 2022) while outdated waste management infrastructure provides low-performance and disposal of waste even in dumpsites as the worst-case scenario for the environment. Therefore, some waste collection services could be provided in communities, but the wastes are uncontrolled disposed of in dumpsites (UNEP, 2024).

These critical infrastructures related to sound waste collection services and safe waste disposal sites are urgent to be addressed in some countries and regions around the globe (Latin America, Eastern and Southeastern Europe, Africa, Asia) in line with target 11.1 of SDGs (UNDP, n.d). Closure and replacement of dumpsites in developing world and non-compliant landfills in EU new member states and EU candidate countries with sanitary landfills linked to material-recovery, composting, and anaerobic digestion facilities constitutes basic infrastructures to prevent environmental contamination and public health threats (Mihai et al., 2024b; Zero-Waste Europe, 2025). However, such systems should take into consideration local circumstances (geographical and socio-economic conditions, cultures, etc. and proper financial mechanisms to help low-income countries improve CE-related infrastructures (Lerpiniere et al., 2025). Before any higher expectations about CE prospects in some places, basic waste, sanitation, and wastewater management services must be seen as a priority. However, there are key actions to help even such communities such as legislation (e.g. single-use plastic ban; plastic importation ban), supporting the informal sector to feed local waste banks with recyclables, creative recycling, repair/reuse at household levels or community centers/workshops, home composting practices, small-scale anaerobic digestion plants with minimal investments. The decentralized solutions supported by waste pickers can help remote regions with poor access to formal waste management to divert wastes from open environments and landfills into local circular economy actions (Circle Economy, 2024). Combined efforts of formal waste-sanitation-wastewater sectors and decentralized systems should be put into operation in neglected communities around the globe (e.g. Asia, Africa, Latin America, and Eastern Europe) to minimize all types of waste streams and untreated wastewater leakage levels into open

environments (Sankara Narayan et al., 2024). Universal access to such public utilities should be regarded as a basic human right nowadays.

4. CIRCULAR AMBITIONS ON "PAPERS" AND MASSIVE POLLUTION IN OPEN ENVIRONMENTS

Urban and rural communities around the globe, including high-income regions (e.g. United States, European Union), are still facing illegal waste disposal practices (e.g. wild dumps, open burning practices, fly-tipping behavior) while the reasons could vary from inefficient waste collection activity, underdeveloped logistics, collections, and disposal in uncontrolled sites, poor law enforcement, payments avoidances (waste management fees), commodity, ignorance, etc. (Duo et al., 2021; Mihai and Ulman, 2024). Business motivations for illegal waste disposal practices need to be accounted for and to assess their impact on regional scales (Troisi et al., 2023). Furthermore, countries are exposed to illegal dumping of industrial and hazardous waste with related impacts on the environment and public health risks (Jiao et al., 2024) while construction and demolition waste are disposed of in open environments despite their recycling and recovery potential (Ramos & Martinho, 2023). Regardless of the local best efforts in managing their domestic wastes, some municipalities are affected by upstream localities. This is the case of macroplastic pollution that is mobilized across a river basin level following flood events as shown in Figure 2.

The transboundary water bodies (rivers/lakes) are also vectors for waste pollution transfers between countries and sub-national regions (Mihai et al., 2024a). Around 40 % of collected municipal waste is open dumped or burned polluting the air-water-soil nexus across the globe (Whiteman et al., 2025). In addition to the waste management sector, outdated and broken sewage systems or wastewater treatment plans lead to cross-border pollution as has happened between the US and Mexico (Project Coronado, n.d). The wastewater treatment facilities require technological upgrades to increase their efficiency in pollutant removal while biosolids need to be integrated into CE mechanisms (Mihai et al., 2023). Using treated sewage sludge and urban compost as fertilizers for agricultural activities is in line with CE principles, but research studies show that soil is exposed to toxic pollutants and microplastics (Gao et al., 2024; Brťková et al., 2024).

Therefore, proper monitoring of fertilizers produced by industrial-scale facilities fed by urban organic waste streams is crucial to avoid releasing pollutants in open environments and minimizing public health threats. Improving the drinking water supply system and providing public water fountains are identified as strategies to reduce water-related plastic packaging in open environments (Government of The Gambia & Common Seas, 2024). Furthermore, coastal and island communities and touristic resorts are affected by marine debris pollution transported by ocean currents from long distances.

These facts point out the key interconnections between waste generation sources and pollution destinations with multi-scale impacts (local-regional-national-global) and waste trades that favor the "waste colonialism" phenomenon by importing waste despite deficient domestic waste management capabilities in receiving countries (Stoett, 2024).

Figure 2. Legacy Plastic Pollution on Bistrita River (Alexandru Cel Bun Municipality, Neamt County, Romania) From Upstream Localities. The local waste management system is regularly provided including for source-separation of dry recyclables such as PET bottles. Photo: Author, September 2024

Furthermore, a small number of plastic-related brands are found in remote locations of marine environments (e.g. Chagos Archipelago, Indian Ocean) and these findings show that EPR policies need to be improved and better enforced (Savage et al., 2024). Open-burning practices raise significant environmental concerns as main disposal routes besides open dumping practices in the Global South because of the uncollected waste generated by 1.5 billion individuals (Cottom et al., 2024). To reduce the scale of open burning practices in sub-Saharan Africa a guide was published to help local authorities in managing this disposal practice, to raise awareness, and to achieve a behavioral change within the community (Guya and Atkins, 2025). On the other side, in Global North regions are still detected pollution sites in surroundings associated with illegal dumping activities or open burning due to the current waste management dysfunctionalities (Alfonso-Torreño et al., 2023) and environmental crimes related to hazardous waste support by business interests (Vitali et al., 2021). To reduce mismanaged waste flows into open environments current systems of waste, sanitation, and wastewater treatment plants need to be further improved to capture as much as possible the diverse range of waste streams generated while waste trades between countries and continents need to be carefully monitored. Mandatory of sorting mixed waste is recommended by Zero Waste Europe at the EU level before being disposed of in landfills or burnt in incineration plants to prevent resource loss (Zero Waste, 2025).

Such regulations could stimulate the resource recovery process in landfilled-based countries, but without neglecting the upstream interventions in the long term. Developed regions need to scale up their domestic circular economy capabilities such as reuse, refill, repair, remanufacture, and recycling systems compared to externalizing solutions such as exports overseas, particularly to the Global South, combined with awareness and law enforcement of communities to support anti-litter and anti-dumping behaviors.

Therefore, the focus of CE ambitions should regard the upstream measures particularly for the business sector under the EPR umbrella to reduce waste generation from the production stage, redesign for better reuse, refilling, and repair, to increase the recyclability and recycled material components in their products (Zero Waste, 2025). However, CE research must take into consideration the rebound effects of CE policies such as increasing consumption of new goods or from second-hand market (e.g. textiles) that could further feed environmental pollution (Castro et al., 2022). Both municipalities and business sectors must play their role in infrastructure and CE policy development (e.g. deposit-return schemes, reuse logistics, EPR policies, zero-waste certification) to increase the circularity levels from local to global levels and to reduce illegal waste disposal practices (e.g. better law enforcement, trackability of waste flows, digital technologies) while citizens should embrace the pro-environmental behavior (e.g. anti-litter awareness, source separation efficiency, home/community composting, zero-waste lifestyle).

5. RECYCLING AND RESOURCE RECOVERY BETWEEN FORMAL, INFORMAL, AND CRIMINAL ORGANIZATIONS

Despite the Basel Convention regulation, the transboundary movement of hazardous waste is still an environmental threat. The international trade includes both legal and illegal activities and in the "name of recycling" several waste streams could be moved from one country to another including textiles, plastics, e-waste, used tires, mixed municipal waste, hazardous wastes, etc. These waste trades should avoid exportation to less developed countries and these should end up in recycling facilities not in open environments, to be dumped, burnt, or buried. Disparities in law enforcement procedures and sanction levels encourage the illegal trade of waste between European countries (Troisi et al., 2023). For example, Romania is exposed to illegal traffic of wastes as a destination and transient route in the EU. The lack of proper documents, falsifying waste types, "donations" and second-hand products that in reality are non-recyclable waste (even hazardous types) pose additional environmental threats if passed border controls (Mihai and Ulman, 2024). These are some of the waste trade-related issues detected by border police while illegal volume traffic stopped at borders in the first 9 months of 2024 is around 7400 tons with a 63 % increase rate compared to the previous year in Romania (Monitorul de Cluj, 2024).

Regarding the urban air pollution issue, waste to energy facilities raises significant public health concerns despite the claim of solving landfill-related problems of a megacity and providing additional energy sources according to an investigation in New Delhi, the capital city of India (New York Times, 2024). Similarly, the use of hazardous wastes, used tires, and mixed wastes, as replacements for fossil fuels as a source of energy in cement factories contributes to air pollution threats as shown in rural communities in Romania while independent air pollution monitoring stations supervised by environmental authorities are insufficient (Mihai and Ulman, 2024).

Urban mining is a core activity in resource recovery operations and material recycling activities such as e-waste and end-of-life vehicles, in line with circular economy ambitions and to avoid new resource extraction. However, there are formal and informal activities, and in the latter case, these pose serious environmental health risks and pollution hotspots in peripheral areas of cities or surrounding rural communities. Ferrous and non-ferrous wastes are demanded items on the recycling market that lead to criminal organizations proliferating in some countries including Romania (Mihai and Ulman, 2024).

The non-recyclable parts of e-waste or end-of-life vehicles are uncontrolled disposed of or buried or burnt in surroundings like Sintesti municipality near the southern part of Bucharest capital city where the Environmental Guard regularly performs field investigations (Europa Libera, 2023). The illegal activities undermine the formal recycling market and also the real data flows for particular waste streams captured by recycling operations (Europol, 2022). The individuals work in rudimentary conditions exposing their health to toxic compounds and entire vulnerable communities could be part of such practices. At the global scale, 80 % of e-waste is assumed to be processed by the informal sector particularly in countries like Ghana, Nigeria, India, Philippines, or China while 85 % of plastic waste is managed by waste pickers in Marocco (Circle Economy, 2024). Also, African countries are exposed to textile waste trades fed by fast fashion business models that led to pollution hotspots.

Poor quality clothes that cannot be reusable end up in open environments, openly burned or burned as a cheap fuel in households with related environmental threats, or sent away to other regions or neighboring countries. The magnitude of pollution related to textile waste is critical as investigated in Ghana (Greenpeace Africa, 2024)

alongside one of the largest e-waste dumps in the world (Zheng et al., 2024). Therefore, on regional and local scales the informal sector plays a key role in waste diversion from landfills and open environments in less developed economies, but these practices need to be safer for both workers and the environment with community support and to minimize the risk of being mobilized by criminal organization schemes. Furthermore, international trade of secondary materials, wastes, "donations" and "second-hand" products should be better controlled at borders by authorities (exporting countries), improving the trackability and international cooperation among countries (including transient routes) to reduce geographical and social injustices of destination countries (Europol, 2022; Mihai and Ulman, 2024; Stoett, 2024).

6. PROGRESS TOWARD A CIRCULAR ECONOMY TRANSITION AND POOR RELIABLE WASTE-RELATED STATISTICS

The circular economy is recognized by scientists, businesses, and policymakers as an important framework to address the triple planetary crisis (climate changes-pollution-biodiversity loss) due to multi-sectoral implications from upstream to downstream sectors. However, CE theory has also critics in the theoretical background (Corvellec et al., 2022) fed by multiple definitions and concepts (Kirchherr et al., 2017) or limited practical implementation prospects (Eickhoff, 2024) and underdeveloped monitoring mechanisms. Policy documents released by organizations argue that CE needs practical, transparent, and scalable solutions supported by the regulatory framework (Circle Economy, 2024; Zero Waste Europe, 2025) tested by various business actors and sectors (e.g. industrial, services, agriculture municipalities) while these efforts should have a more homogeneous geographical distribution (Tsironis et al., 2024).

The progress of circular economy from micro to national or international levels requires dedicated indicators and data feed from business actors and municipalities. Waste statistics at subnational levels lack, are outdated, or unreliable undermining efforts to assess the waste flows at a detailed level (Mihai et al., 2024). National-level data have a better availability but with no relevance to depict regional disparities important to determine waste leakage levels into open environments or to properly assess the waste diversion towards CE pathways. Eurostat data provide several waste-related data and indicators broken down per various waste streams (e.g. municipal waste, packaging waste, e-waste), but the last available data are behind 2 years.

We need more updated, available, and timely data at national and subnational levels (municipalities) plus the waste flows derived from international trades with environmental repercussions for some geographies (Asia, Africa, and Eastern and Southeastern Europe). Some waste streams (agricultural and industrial waste) are less available compared to municipal waste or packaging waste. Furthermore, neither national-level data are trustworthy for many countries (UNEP, 2024). This situation constitutes barriers to revealing the CE progress on the downstream level and even at the national level. For example, data gaps and inconsistent metrics are mentioned as drawbacks for regional circular economy monitoring in France (Bourdin and Jacquet, n.d.) while a new update report shows that the circularity metric in the high-income country of Norway is stuck at 2 % (Circle Economy, 2025). The European Court of Auditors signals several dysfunctionalities regarding the availability and reliability of plastic packaging recycling data in the EU while mentioning the lucrative illegal business activities made by criminal organizations in this sector (ECA, 2024). Eurostat does not perform checks regarding the recyclers, thus, the data reporting system could not reflect the current realities (ECA, 2024). Furthermore, the European Commission calls on all Member States to meet waste collection and recycling targets as an infringement decision in 2024 failing to comply with targets for preparing for reuse and recycling of municipal waste (European Commission, 2024). Bio-waste is a key resource for CE, but source separation is not performing well across Europe and a recycling rate of 65% by 2035 could not be achieved in a business-as-usual scenario (Zero Waste, 2025). Furthermore, the data gaps related to an insufficient data monitoring system and low geographical coverage of source separation are significant barriers to a circular bioeconomy transition in the EU (Nohales and Stinavage, 2024). There are still gaps between Western Europe and Eastern Europe regarding CE performances and a more comprehensive database is needed for future progress analysis (D'Adamo et al., 2024).

An open letter signed by NGO's business and other organization representatives addressed to the European Parliament demands several actions to accelerate the CE transition in Europe including decisive actions against incorrect transposition and non-compliance of policies (Zero Waste Europe, 2024). EU policies related to CE are

fragmented among diverse sectors and a new commissioner dedicated to CE may provide more cohesion in the near future (Darut, 2024). The Circular Cities Declaration aims to reveal the current progress of European cities towards a circular economy transition, thus 56 reporting cities from 18 countries and 16 million inhabitants send their data to provide a snapshot of current status and specific challenges providing valuable feedback from municipalities (Circular Cities Declaration, 2024). A platform dedicated to circular jobs and the impact of CE actions at the city level has been launched for Gamagori in Japan (CGRI, nd.) Such initiatives should cover diverse geographies to depict the national and subnational efforts made toward a CE transition. A circular economy requires standardization among diverse stakeholders regarding the use of secondary materials in economies for better traceability and performance analysis (ISO, 2024). A packaging business coalition joined forces to support the reuse system in Europe and to establish standards for databases of products accepted for reuse and data infrastructures (NewReuseAlliance, nd). The business initiatives and municipalities must contribute to the development of CE database infrastructures.

7. PLASTICS TREATY BETWEEN HIGH AND LESS AMBITIOUS COUNTRIES AND IMPLEMENTATION PROSPECTS

The ongoing Plastics Treaty under the UN umbrella is a complicated process raising concerns about the division between high-ambitious and less-ambitious countries and lobbying made by petrochemical industries to avoid a cap on plastic production (The Guardian, 2024). This treaty must implement the full cycle of plastics approach to enable both upstream and downstream efforts to end plastic pollution in the following decades and to eliminate the chemicals of concern from plastic production. Transparency and traceability of plastics and chemicals of concern along the supply chain are the keys to implementing, monitoring, and evaluating the progress of the treaty (Wagner et al., 2024). The science-based facts are essential in these negotiations to sustain an effective treaty. Scientist's Coalition for an Effective Plastics Treaty (SCEPT) provides such scientific facts based on peer-reviewed academic research publications in policy briefs format, and recommendations for key topics relevant to an ambitious Plastics treaty supporting the full cycle approach of plastics that includes circular economy aspects (SCEPT, 2023). The Business Coalition for a Global Plastics Treaty supports reductions and circulation of plastics emphasizing the role of a circular economy in their vision for sustainable business practices (Business Coalition for a Global Plastics Treaty, 2022). However, the plastics treaty text will be decided by national delegation representatives followed by ratification procedures. A key stage will be the enforcement procedures through national action plans and regional institutions' involvement while the participation of businesses, municipalities, and civil society will be crucial to implement both upstream and downstream CE routes to reduce plastic pollution, plastic production chemicals of concern, and plastic consumption while maximizing efforts towards environmentally friendly plastic alternatives and substitutes. For example, Gambia elaborated a national action plan to end plastic pollution aiming to reduce this environmental threat by 84 % over 10 years (Government of The Gambia & Common Seas, 2024). There are 67 countries members of the so-called "High Ambition Coalition to End Plastic Pollution" that recognize the need for the full cycle approach of plastics and a target to end plastic pollution by 2040 (HAC, 2024). These ambitions are also supported by landfill-based countries (e.g. Romania, Rep. of Moldova, Georgia) that need to scale up the following years the reuse-refill-remanufacture-recycling operations in their waste management systems and apply and monitor EPR policies for the business sector (Mihai et al., 2024b).

Furthermore, there are countries and civil organizations that desire to cap and reduce primary plastic production products and signed a common declaration in this regard (BridgetoBusan, 2024), but several countries (e.g. the U.S., Argentina, Egypt, China, India, Indonesia, Saudi Arabia, Russia) are not on the list of signatories so far. A detailed report about country positions in these negotiations (until the Busan meeting) broken down per 22 sections of the Plastic Treaty (Biswas and Singh, 2024) reveals the debates and challenges to reach a consensus, and opposite sides regarding upstream measures compared to lower ambitions countries with focus oriented to downstream measures (e.g. Russia, Kazakhstan, Iran, India, Saudi Arabia, Kuwait). Health professionals around the world require an ambitious Plastics Treaty to prevent plastic pollution and related chemicals associated with the complex health sector (Health Care Without Harm, 2024) pointing out that medical products should not be excluded from the treaty negotiations (Street et al., 2024). This multi-sectoral signal to UN delegations and the international community shows that the plastics problem requires a full life cycle approach with a focus on upstream sectors

based on scientific evidence and transparency. SCEPT elaborated a page document regarding what is needed from a scientific point of view for this Plastics Treaty to succeed (SCEPT, 2024).

The Busan meeting in November-December 2024 (Fifth Intergovernmental Negotiating Committee - INC-5.1) failed to conclude a Plastics treaty. However, this meeting ended up with a Chair's text to be further discussed in negotiations at the second part of the meeting in Geneva (5-14 August 2025 as INC 5.2) to reach a global agreement among countries (Chair's text, 2024). The international organizations publish their views on this document to improve the shortcomings and strengthen the treaty in the next INC meeting (IPEN, 2025; GAIA, 2025). Nevertheless, there is a great division between fossil fuels exporters (Russia, Iran, Saudi Arabia) that focus on the downstream sector (e.g. waste management, removal, and remediation) compared to the full cycle approach and plastic production caps supported by a coalition led by Norway and Rwanda (Shah and Wu, 2025). The "Coalition of the Willing" formed during the Busan meetings, which comprised around 100 countries led by Rwanda, Panama, Mexico, France, Fiji, and the European Union, could catalyze future negotiations in Geneva to reach a higher ambition consensus while the access of observers (independent scientists and non-government organizations) to the INC 5.2 meetings should be better supported (Farrely et al., 2025).

8. CIRCULAR BUSINESS MODELS AND GREENWASHING RISKS

In addition to municipalities and "consumers" of products and services, the business sector must be responsible for upstream innovation (redesign, re-think) and reducing wastes from the manufacture/production stage in line with the zero-waste hierarchy approach (Zero Waste Alliance, n.d). The public awareness and pressure on the waste pollution crisis is increasing and it requires systematic changes for businesses to adjust to new policies and regulations despite their tactics to manufacture doubt in public discourse (Goldberg and Vandenberg, 2021). Therefore, conflict of interests must be properly managed while examining and monitoring the international agreements related to chemicals, waste, and pollution (Schäffer et al. 2023). Similar to the climate change topic, the circular economy could be exposed to diverse obstruction practices of fossil fuels industries' interests (Hiltner et al., 2024) particularly related to plastic production and management. There is a lawsuit against a petrochemical corporation in California (US) for misleading public regarding the plastic recycling practices (NPR, 2024) while field investigations show the "waste colonialism" effects of UK textile waste exportation to Ghana (Britten, 2024).

Furthermore, fake results in plastic recycling reporting were detected in Spain (Zero Waste Europe, 2024b) while fashion industries apply delay tactics in reducing fossil-fuel-based synthetic fibers responsible for microplastic contamination of the environment and human health (Changing Markets 2024). The circular economy is a pivotal framework for a cleaner environment, but a lack of transparency, data, and knowledge gaps could feed greenwashing practices as happened in climate change (CIEL, 2024). Some EU business representatives draw attention in an open letter to the unfulfilled commitments regarding carbon emissions and renewable energy investments in the business sector and demand for an industrial green deal with circularity as a core concept while enforcement of EU legislations must improve (Triodos Bank, 2024).

Therefore, the risks related to greenwashing practices need to be examined otherwise the enforcement of key waste-related policies (e.g. EPR) will make it difficult to monitor and assess its progress and determine reliable business circular models (Mihai and Ulman, 2023). Stakeholders involved in CE in Europe demand that the EPR schemes be supervised and monitored by an independent body (Zero Waste Europe, 2024a). Against this background, a global circularity protocol is envisioned to be adopted by business sectors to standardize the assessment and data quality related to circularity (WBCSD, 2024). Businesses around the world claim to adopt circular economy mechanisms through Rs policies, the most prevalent being recycle, reduce, renew, reuse, and recover, while geographical distribution shows a significant gap between the global north and south in terms of companies number (Tsironis et al., 2024). However, these claims need to be supported by evidence-based findings, transparency, and empirical data, and verified by independent organizations. In this regard, certification procedures such as "zero-waste business" dedicated to hotels, restaurants, offices, and events provide specific strategies to implement circular economy measures (Mission Zero Academy, nd). The circular business models at the micro level (business unit level) are the first steps towards a circular economy transition (Geissdoerfer et al., 2020). These models need to be scalable to other regions or adjusted to local circumstances using relevant metrics in their performance assessment (Elia et al., 2024). Their cumulative actions could catalyze the local incentives through multi-sectoral interconnections.

These collaborations could enable a transition towards a CE transition from micro to municipal level (urban or rural). The first edition of the reuse barometer in Europe reveals some good practices made by business actors in reusable packaging, and the efficiency of deposit-return schemes and points out the need to fill the current data gaps (InOff Plastics, 2024). Transparent reporting is one of 10 key objectives assumed by multisectoral packaging business alliance (collection, tracking & washing; retail; takeaway; e-commerce and transport, beverage) in supporting reuse systems in Europe (NewReuseAlliance, n.d). A new report in the UK argues that the take-back system promoted by supermarkets is misleading customers because the UK recycling infrastructures for soft-packaging materials do not cope with the levels put on the market, thus, GPS tracking investigations found these items end up in waste to energy facilities or exported in Europe and beyond (Everyday Plastic and EIA 2024). Multinational corporations must be accountable for their waste production (Cowger et al., 2024) and EPR policies should extend their geographical coverage to reduce the pressure on downstream levels in less developed regions.

9. SMART CITIES AND NEGLECTED RURAL COMMUNITIES

Digital technologies can help to improve current waste management practices as part of the Industry 4.0 revolution (Kannan et al., 2023). This technological-oriented approach is supported by a smart city agenda where public utilities (waste, water supply, sanitation, public transportation, energy) are optimized using real-data time through sensors, GPS tracking systems, the Internet of things, and other technological tools. For example, waste collection optimization (routes/transport), or source-separated collection (bins with sensors) are already used as part of so-called "smart waste management systems" (Olawade et al., 2024). The efficiency of collection and waste sorting services will reduce the contamination risks with other waste streams and the waste leakage risks to open environments while increasing waste diversion rates from landfills towards reuse, refilling, repair, recycling systems for non-organic streams and composting/anaerobic digestion for organic waste flows as shown in figure 3.

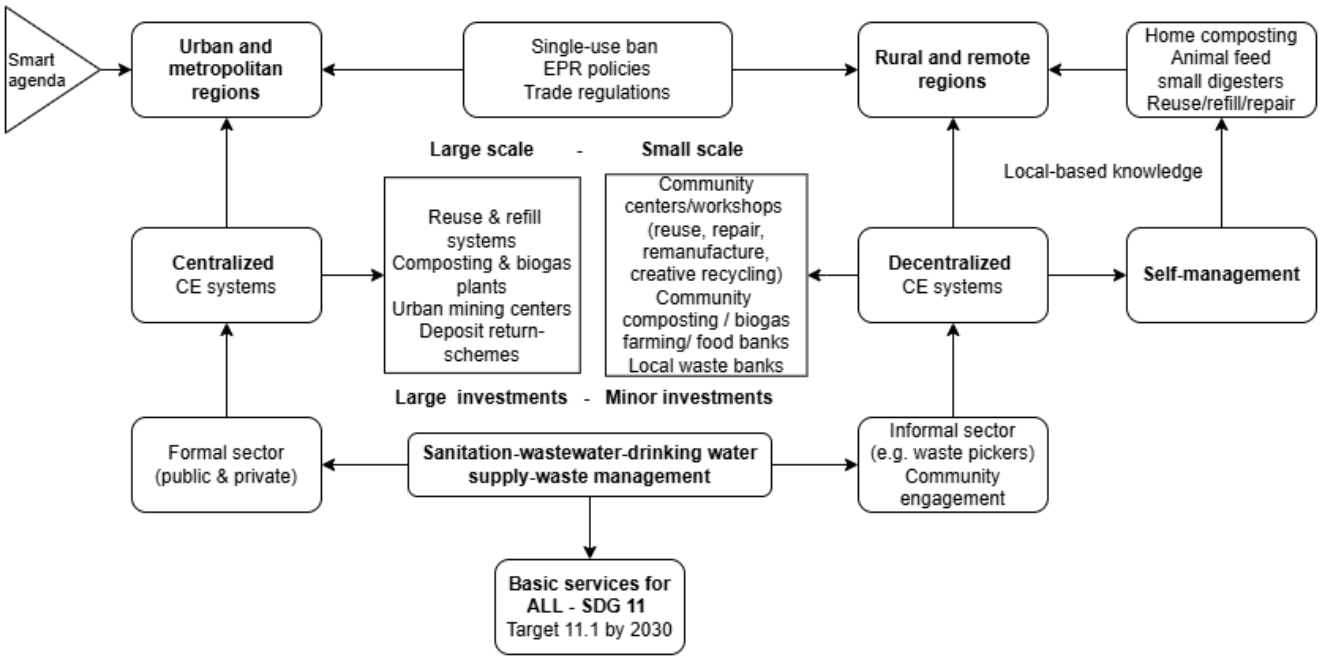

Figure 3. Centralized and Decentralized Solutions to Provide Basic Services for All and Adopting CE Actions at the Subnational Level Including Both Urban and Rural Regions. Source: Author

On the other side, law enforcement regarding anti-dumping practices and environmental awareness are other positive outcomes with the help of digital technologies such as remote sensing data, GIS applications, drones, etc. (Kruse et al., 2023). Despite the emergence of these technologies in urban centers, the distant rural regions in middle and low-income countries are facing underdeveloped public services. The urban-rural gaps in providing sound waste

management and sanitation services need to be reduced particularly in less developed regions (Mihai, 2017; World Risk Poll, 2024) and digitalization of public utilities could enhance this cohesion process at least in the metropolitan and peri-urban areas around the globe or tourist destinations. Rural regions have a deficient circular economy infrastructure compared to urban areas in Eastern Europe (Mihai et al., 2024b) while rural population perceptions is that of being more exposed to illegal waste disposal practices in rural Scotland (Malcolm et al. 2024).

Regional waste management plans that imply a city and surrounding rural communities are necessary to track these waste flows between waste generation sources and treatment operations or safe disposal sites. The key is to provide decentralized reuse-refill-repair-remanufacture-recycling centers for distant rural communities integrating the role of the informal sector and community support to such locally based knowledge activities in developing regions as shown in Figure 3. In addition, decentralized wastewater systems need to be adopted in rural communities without a formal infrastructure in developing countries (Muzioreva et al., 2022). Biogas production and natural fertilizers in small-scale plants could prevent the organic waste pollution produced by farmers through inadequate agricultural waste management practices in rural regions (O'Connor et al, 2021).

A circular economy strategy guideline for cities was released as a significant step in policy commitment to pursue a circular economy transition at the city level (Circle Economy, 2022) and updated strategies are already assumed in the next years (City of Amsterdam, n.d). Such specific guidelines could benefit rural municipalities including urban-rural collaborations. Zero-waste municipality certification involves both urban and rural municipalities in the CE transition with already some successful stories in rural communities (ZeroWaste Romania, 2022) or tourist destinations like the zero-waste island achievement of Tilos in Grecce supported by a public-private partnership (Just Go Zero Tilos, n.d).

The main barrier to the development of circular economy activities in European rural regions is the lack of skilled labor and some regions try to attract younger generations with start-up initiatives and to raise civil society awareness and implications as a form of a local identity while increasing networking and supporting industrial symbiosis among regional stakeholders (Federal Ministry for Housing, Urban Development and Building, 2023). A study from Spain reveals that CE companies in rural areas demonstrated their financial sustainability in addition to environmental ones (Magdalena et al., 2025) while better connectivity and digitalization could attract further investments in rural economies (Cherrington et al., 2024). Depending on the local circumstances of rural communities the CE activities could be improved by (i) decentralized and cost-efficient solutions using both innovative business solutions and traditional or indigenous knowledge (ii) centralized and integrated waste management systems supported by the digitalization process following the smart agenda from urban areas. In both cases, stakeholders' collaboration and community participation are crucial to implementing CE activities that target both efficient material use and renewable energy transition including bio-waste as biogas production through large or small-scale anaerobic digestion facilities. Better monitoring of international trade and EPR policies' effectiveness at subnational levels will benefit both urban and rural regions.

10. CONCLUSIONS

We live in a linear prevalent world and a circular economy transition will be made with multi-sectoral approaches and multi-levels from micro (business unit) towards urban and rural municipalities, regions, and countries, or global levels based on both centralized and decentralized solutions. The role of this paper is to underline some barriers in the current circular economy transition using an antagonism approach and outline the contrasting topics in CE discourse that require more attention from scientists, policymakers, businesses, and civil organizations in the near future. These risks and concerns need to be minimized (mismanaged waste, illegal waste trade, criminal organizations, greenwashing, data gaps, rebound effects) as well as geographical and social inequalities, and urban-rural disparities, and to move from less (downstream) to higher ambitions (upstream) under the EPR framework to provide a reliable transition towards a functional circular economy in an interconnected world with variable impacts in diverse geographies. Based on this literature review future CE research should address the following aspects: (i) to reduce the related risks for upstream and downstream CE routes (ii) to improve the data, transparency, and reduce knowledge gaps in multi-sectoral scopes (academic, business, decision-makers, civil society) (iii) to reduce the existing inequalities at subnational and international levels (iv) to improve the cohesion policies between upstream and downstream routes to support scalable CE actions.

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