Implementing Circular Economy Strategies in Municipal Waste Systems: A ReSOLVE Framework Analysis of UK Cities

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DOI: https://doi.org/10.51584/IJRIAS.2026.11060083

Received: 04 June 2026; Accepted: 10 June 2026; Published: 24 June 2026

ABSTRACT

The transition towards a circular economy (CE) has become increasingly important in addressing the environmental and resource challenges associated with conventional waste management systems. As major generators of municipal waste, cities play a critical role in implementing circular economy principles through policies, infrastructure, and community engagement initiatives. Despite growing interest in circular economy practices, limited research has examined how municipal waste systems in UK cities are applying these principles in practice. This study evaluates the implementation of circular economy strategies in the municipal waste systems of London, Bristol, Manchester, Glasgow, and Cardiff using the ReSOLVE framework, which comprises six action areas: Regenerate, Share, Optimise, Loop, Virtualise, and Exchange.

A qualitative comparative case study approach was adopted, drawing on secondary data from policy documents, municipal reports, government publications, and peer-reviewed literature. The data were analysed thematically to assess the extent to which each city has incorporated circular economy principles into its waste management system.

The findings reveal notable differences in circular economy implementation across the selected cities. The study highlights the importance of governance coordination, financial investment, digital innovation, and community engagement in advancing circular economy transitions at the municipal level. By applying the ReSOLVE framework to a comparative analysis of UK cities, this research contributes to a deeper understanding of the opportunities and challenges associated with implementing circular economy strategies within urban waste management systems and provides practical insights for policymakers and local authorities seeking to strengthen circularity in the waste sector.

Keywords: Circular economy; municipal waste management; ReSOLVE framework; Urban sustainability; Recycling; Governance; United Kingdom.

INTRODUCTION

The increasing pressures of resource depletion, environmental degradation, and climate change have intensified the search for more sustainable approaches to production and consumption. For decades, economic development has largely followed a linear model characterised by the extraction of raw materials, production of goods, consumption, and disposal of waste. Although this model has contributed significantly to economic growth, it has also generated substantial environmental challenges, including rising waste volumes, greenhouse gas emissions, and the unsustainable exploitation of natural resources (European Parliament, 2023). As concerns about environmental sustainability continue to grow, policymakers, researchers, and industry stakeholders have increasingly turned their attention to the concept of the circular economy (CE) as a potential solution.

The circular economy is widely recognised as a regenerative economic system that aims to minimise waste generation and maintain the value of products, materials, and resources for as long as possible through strategies such as reuse, repair, remanufacturing, refurbishment, and recycling (Ellen MacArthur Foundation,

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue VI June 2026

2023). Unlike the traditional linear model, the circular economy seeks to close material loops and reduce dependence on virgin resources while simultaneously supporting economic development and environmental protection (Calisto Friant et al., 2023). Consequently, the transition towards circularity has become a central objective within sustainability agendas at international, national, and local levels.

Municipal waste management systems play a critical role in advancing circular economy objectives because they determine how waste materials are collected, sorted, processed, recovered, and reintroduced into productive use. Poorly managed waste systems can contribute to water quality degradation through the release of contaminants into surrounding aquatic environments. Evidence from river monitoring studies has demonstrated that pollutant concentrations such as ammoniacal nitrogen and chloride can vary significantly over time, reflecting the influence of human activities, infrastructure performance, and environmental management practices (Omoataman, 2025). This further highlights the importance of circular economy strategies that prioritise waste prevention, resource recovery, and pollution reduction. Growing concerns regarding secondary pollutants, particularly microplastic contamination in urban freshwater systems, have further reinforced the need for integrated and preventive approaches to waste management and resource recovery. Recent evidence from UK catchments indicates that urban waterways remain vulnerable to microplastic accumulation arising from human activities and waste leakage pathways, highlighting the environmental importance of effective municipal waste management systems (Owhe, 2026). As centres of population, economic activity, and consumption, cities generate substantial quantities of municipal solid waste and therefore represent important locations for the implementation of circular economy strategies (Malinauskaite & Jouhara, 2017). Urban areas also provide opportunities for testing innovative approaches to waste prevention, resource recovery, and community engagement, making them particularly relevant for assessing practical applications of circular economy principles.

In the United Kingdom, municipal waste management has undergone significant transformation over the past two decades. Policy interventions aimed at reducing landfill dependency, improving recycling performance, and promoting resource efficiency have contributed to measurable improvements in waste management outcomes. The implementation of the European Union Landfill Directive, alongside subsequent national waste strategies, encouraged local authorities to divert waste from landfill through recycling, energy recovery, and resource recovery initiatives (OECD, 2021). According to recent national statistics, the UK household waste recycling rate increased to approximately 45% in 2023, while biodegradable municipal waste sent to landfill continued to decline (GOV.UK, 2024).

Figure 1: Recycling rate from waste from households, UK and country split, 2010 to 2023 (GOV.UK, 2024)

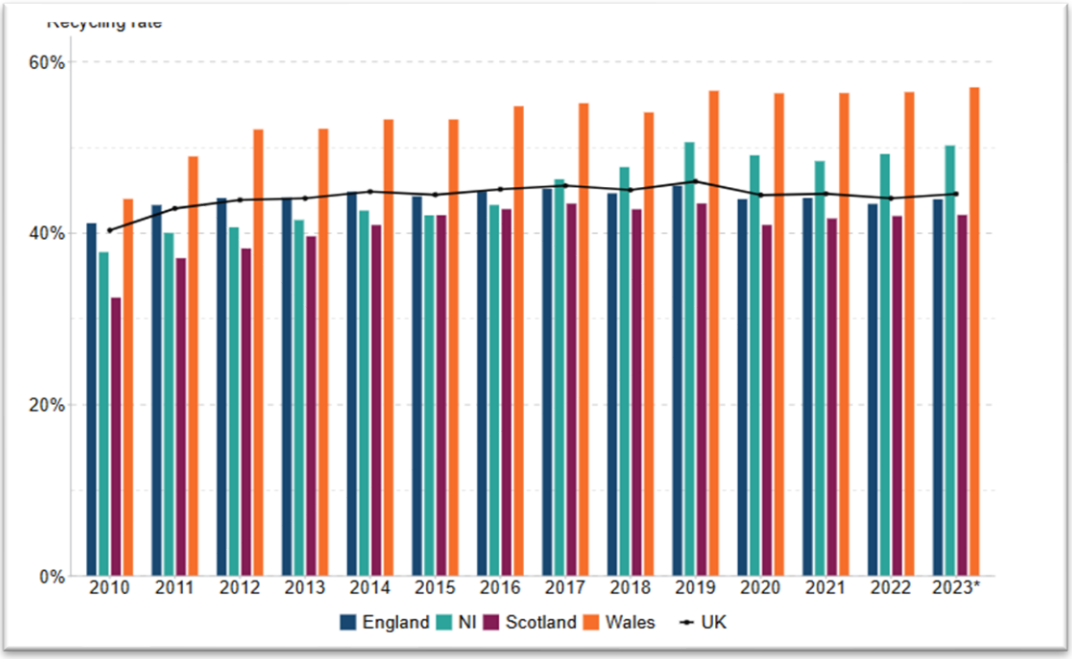

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Figure 1 illustrates the trend in household waste recycling across the United Kingdom and its constituent nations between 2010 and 2023. Wales consistently achieved the highest recycling rates, reaching 57% in 2023, followed by Northern Ireland (51%), England (44%), and Scotland (42%). These differences demonstrate how policy approaches and local implementation strategies can influence recycling performance across jurisdictions

Figure 2: Biodegradable municipal waste to landfill UK and country split, 2010 to 2023 (GOV.UK, 2024)

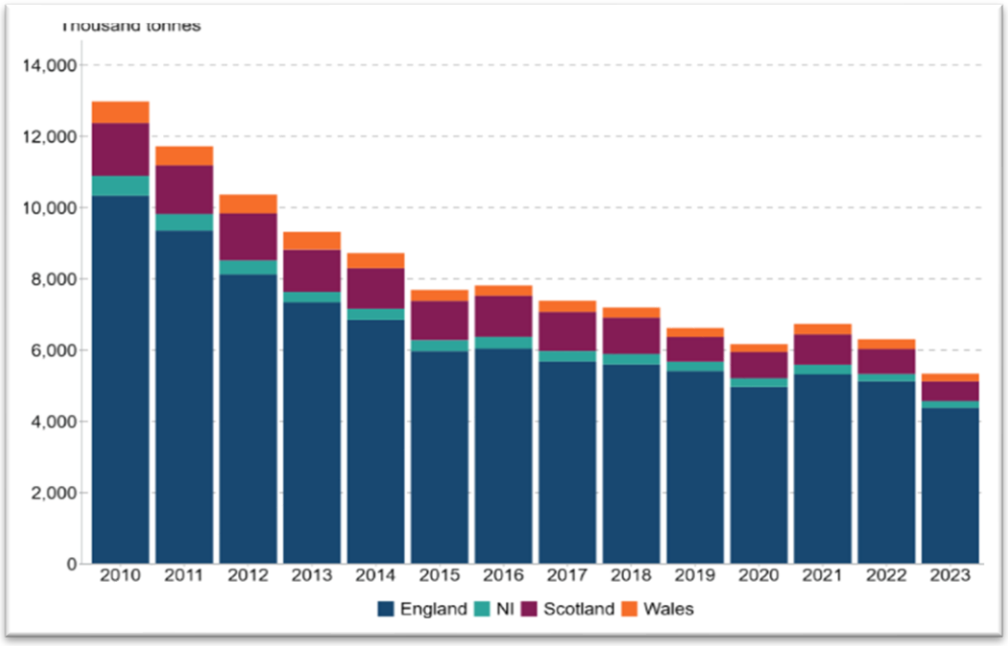

Figure 2 demonstrates a significant decline in biodegradable municipal waste disposed of in landfill across the United Kingdom between 2010 and 2023. The reduction reflects the impact of landfill taxes, diversion policies, recycling initiatives, and investments in alternative treatment technologies. In 2023, biodegradable municipal waste sent to landfill decreased to approximately 5.3 million tonnes compared with 6.3 million tonnes in 2022, indicating continued progress towards resource recovery and circular waste management objectives (GOV.UK, 2024).

Figure 3: Waste generation by waste material, UK (GOV.UK, 2024)

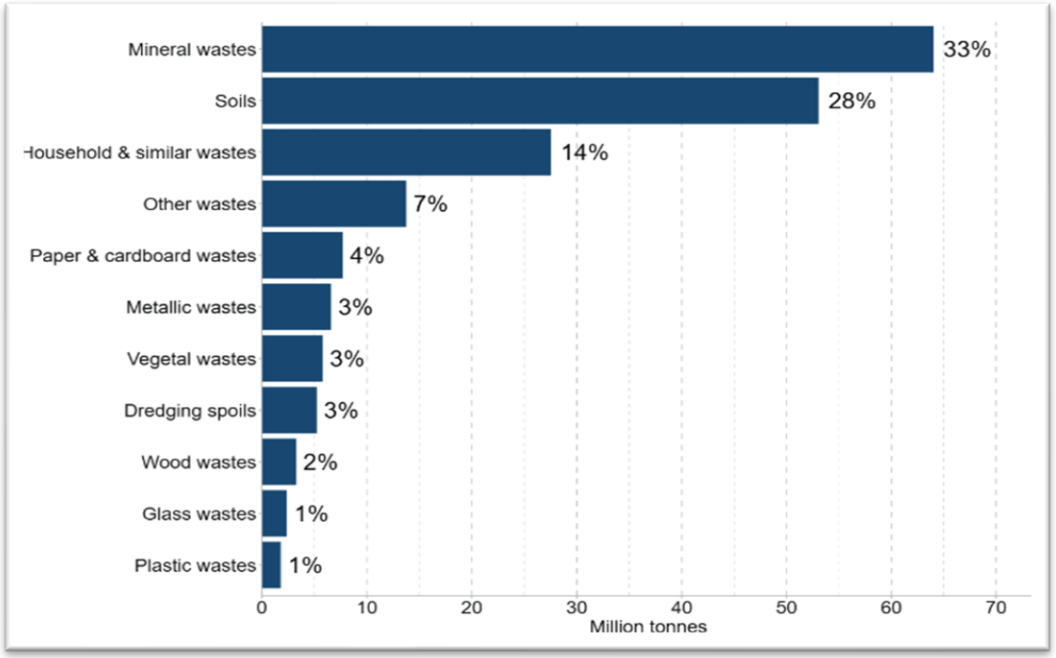

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Figure 3 presents the distribution of waste generated across different material categories in the United Kingdom based on the European Waste Catalogue classification system. The figure highlights the complexity of waste streams and demonstrates that effective circular economy implementation requires interventions beyond household recycling alone.

Recent statistics indicate strong performance in packaging waste recycling. In 2024, packaging recycling rates reached 64.1% under the first reporting methodology and 75.2% under the second methodology. Material-specific performance varied considerably, with paper and cardboard achieving recycling rates of approximately 86.4%, glass and metal reaching 80.4%, and plastics achieving 53.7% (GOV.UK, 2024).

Waste generation also remains significant across commercial, industrial, construction, and demolition sectors. Commercial and Industrial (C&I) waste in England amounted to approximately 32.6 million tonnes in 2023, while Construction and Demolition (C&D) activities generated approximately 63.0 million tonnes of waste, of which around 59.4 million tonnes were recovered. These figures demonstrate both the scale of resource consumption and the opportunities for circular economy strategies aimed at improving material recovery, reuse, and resource efficiency across multiple sectors.

Despite this progress, considerable challenges remain in achieving a fully circular waste management system. Several factors continue to constrain the effective implementation of circular economy strategies within municipal waste systems. These include fragmented governance arrangements, financial limitations, infrastructure constraints, and varying levels of public participation in recycling and reuse programmes (Martin et al., 2024). In addition, local authorities often face competing priorities and resource pressures that can hinder investment in innovative technologies and circular infrastructure. Differences in socio-economic conditions, housing characteristics, and policy implementation further contribute to variations in performance between cities (Calisto Friant et al., 2023).

At the same time, UK cities have increasingly emerged as important centres of circular economy innovation. Local authorities, businesses, and community organisations have developed a range of initiatives aimed at reducing waste generation, promoting reuse, increasing recycling rates, and improving resource efficiency. Examples include digital waste tracking systems, food waste recovery programmes, repair and reuse schemes, and investments in anaerobic digestion infrastructure (Mayor of London, 2018; ReLondon, 2025). These developments suggest that cities can play a pivotal role in driving the transition towards more sustainable and circular waste management systems.

Although the academic literature on the circular economy has expanded considerably in recent years, much of the existing research remains focused on conceptual discussions, national policy frameworks, or individual case studies. Comparative studies examining how circular economy principles are implemented across different municipal contexts remain relatively limited, particularly within the United Kingdom. Furthermore, many studies emphasise recycling performance and waste management outcomes without systematically assessing how broader circular economy principles are embedded within municipal governance structures, infrastructure systems, and community initiatives (Savini, 2023).

To address this gap, this study applies the ReSOLVE framework developed by the Ellen MacArthur Foundation as an analytical lens for examining circular economy implementation within municipal waste systems. The framework identifies six key action areas: Regenerate, Share, Optimise, Loop, Virtualise, and Exchange which collectively provide a comprehensive approach for assessing circular economy practices across different contexts (Williams, 2016). By employing the ReSOLVE framework, this research moves beyond conventional recycling indicators to evaluate the wider dimensions of circularity within urban waste management systems. The study focuses on five UK cities: London, Bristol, Manchester, Glasgow, and Cardiff which were selected because they represent diverse governance structures, policy environments, demographic characteristics, and approaches to waste management. These cities provide valuable case studies for exploring how circular economy strategies are interpreted and implemented at the municipal level.

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The research is guided by the following questions:

1: How are circular economy principles being incorporated into municipal waste systems across selected UK cities?

2: Which dimensions of the ReSOLVE framework are most and least developed within current municipal waste management practices?

3: How do governance structures, infrastructure systems, and policy environments influence circular economy implementation across UK cities?

By addressing these questions, the study contributes both theoretically and practically to the growing body of circular economy research. Theoretically, it demonstrates the application of the ReSOLVE framework as a tool for evaluating municipal circular economy initiatives. Practically, it provides evidence-based insights that can support policymakers, local authorities, and waste management practitioners in designing more integrated and effective strategies for advancing circularity within urban waste systems.

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Circular Economy and Municipal Waste Management

The concept of the circular economy (CE) has emerged as a response to the environmental and economic limitations associated with the traditional linear model of production and consumption. The linear economy is characterised by the extraction of raw materials, manufacturing, consumption, and disposal, resulting in significant waste generation and resource depletion. In contrast, the circular economy seeks to maintain the value of products, materials, and resources within the economy for as long as possible while minimising waste and environmental impacts (Ellen MacArthur Foundation, 2023). Although there is no universally accepted definition of the circular economy, most interpretations emphasise resource efficiency, waste prevention, material recovery, and the regeneration of natural systems (Kirchherr et al., 2017). The circular economy extends beyond recycling by encouraging strategies such as reuse, repair, refurbishment, remanufacturing, and product life extension. These approaches aim to reduce dependence on virgin materials while promoting sustainable patterns of production and consumption (Calisto Friant et al., 2023).

Municipal waste management systems occupy a central position within circular economy transitions because they influence how materials are collected, sorted, processed, and returned to productive use. Historically, waste management policies focused primarily on collection and disposal. However, the growing recognition of waste as a potential resource has encouraged a shift towards more integrated approaches that prioritise waste prevention and resource recovery (Malinauskaite & Jouhara, 2017). Consequently, municipal waste systems have become important mechanisms through which circular economy principles can be translated into practical action.

Several studies have highlighted the importance of local governments in facilitating circular economy implementation. Municipal authorities are responsible for key functions including waste collection, recycling services, public awareness programmes, infrastructure planning, and regulatory enforcement. Their decisions directly influence recycling performance, public participation, and resource recovery outcomes (Martin et al., 2024). As a result, cities are increasingly viewed as critical actors in advancing circular economy objectives.

Despite growing policy support, implementing circular economy principles within municipal waste systems remains challenging. Financial constraints, fragmented governance arrangements, infrastructure limitations, and behavioural factors continue to hinder progress in many urban areas (Finamore & Oltean-Dumbrava, 2024). Furthermore, differences in local priorities, socio-economic conditions, and policy implementation often result in significant variation in performance between cities. These challenges highlight the need for comparative studies that examine how circular economy strategies are implemented within different municipal contexts.

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Circular Economy Implementation in Urban Contexts

Cities have become increasingly important laboratories for circular economy innovation because of their concentration of population, economic activity, and material consumption. Urban areas generate substantial volumes of municipal waste while simultaneously possessing the institutional capacity and infrastructure required to implement circular economy initiatives (Elroi et al., 2023). Consequently, many cities have adopted policies and programmes aimed at reducing waste generation, increasing recycling rates, and promoting resource efficiency.

Research has identified several factors that influence the success of municipal circular economy initiatives. Governance is frequently cited as one of the most significant determinants of implementation effectiveness. Strong institutional coordination, clear policy direction, and collaboration among stakeholders are often associated with better waste management outcomes (Martin et al., 2024). Conversely, fragmented governance structures can create inconsistencies in service delivery, policy implementation, and long-term planning.

Infrastructure also plays a critical role in supporting circular economy transitions. Recycling facilities, material recovery centres, anaerobic digestion plants, and digital waste monitoring systems provide the physical foundation necessary for resource recovery and circular material flows (OECD, 2021). Cities that invest in modern waste management infrastructure are generally better positioned to achieve circular economy objectives than those relying on traditional disposal-based systems.

Public participation represents another important dimension of successful implementation. Recycling, reuse, and repair initiatives depend heavily on citizen engagement and behavioural change. Previous studies have demonstrated that awareness campaigns, educational programmes, and community-based initiatives can significantly improve participation rates and contribute to higher levels of material recovery (Calisto Friant et al., 2023). However, participation levels often vary according to demographic, cultural, and socio-economic factors, creating additional challenges for local authorities.

Within the United Kingdom, several cities have introduced innovative circular economy initiatives in response to national sustainability objectives. These initiatives include food waste collection programmes, repair and reuse networks, resource recovery partnerships, and digital waste management systems (Mayor of London, 2018). However, the effectiveness of these interventions varies considerably across locations, reflecting differences in governance capacity, funding availability, infrastructure provision, and public engagement. Comparative evaluation of these experiences remains relatively limited within the existing literature.

The ReSOLVE Framework

To evaluate circular economy implementation within municipal waste systems, this study adopts the ReSOLVE framework developed by the Ellen MacArthur Foundation (2015). The framework was designed to assist organisations, governments, and policymakers in identifying practical actions that support the transition towards a circular economy. ReSOLVE provides a structured approach for assessing circularity through six interconnected action areas: Regenerate, Share, Optimise, Loop, Virtualise, and Exchange.

The Regenerate dimension focuses on restoring and enhancing natural systems while reducing dependence on finite resources. In municipal waste management, this may involve composting programmes, organic waste recovery, renewable energy integration, and initiatives that contribute to ecosystem restoration (Ellen MacArthur Foundation, 2015).

Share emphasises maximising product utilisation through sharing, maintenance, repair, and reuse activities. Municipal initiatives such as repair cafés, reuse centres, community exchange schemes, and sharing platforms contribute to this dimension by extending product lifespans and reducing waste generation.

Optimise seeks to improve resource efficiency by eliminating waste, increasing system performance, and enhancing operational effectiveness. Examples within municipal waste systems include smart collection

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technologies, route optimisation systems, digital waste tracking, and data-driven service improvements (Williams, 2016).

Loop focuses on keeping materials in productive use through recycling, remanufacturing, and resource recovery processes. This dimension is particularly relevant to municipal waste management because recycling systems represent one of the most visible mechanisms through which materials are returned to economic circulation.

Virtualise involves replacing physical products or activities with digital alternatives where feasible. Examples include digital service delivery, electronic documentation, online platforms, and smart technologies that reduce material consumption while maintaining service provision.

Exchange encourages the adoption of advanced technologies, innovative materials, and alternative business models that support circular economy objectives. Within municipal contexts, this may include investment in waste treatment technologies, renewable energy systems, and innovative resource recovery infrastructure.

The ReSOLVE framework has been widely recognised as one of the most comprehensive tools for operationalising circular economy principles because it extends beyond traditional waste management indicators and captures broader dimensions of circularity (Williams, 2016). Unlike approaches that focus solely on recycling performance, ReSOLVE facilitates a more holistic assessment of how organisations and cities create, maintain, and recover value from resources.

For this reason, the framework provides an appropriate analytical lens for examining municipal waste systems across the selected UK cities. By applying the six dimensions of ReSOLVE, the study is able to identify both strengths and weaknesses in current circular economy practices while providing a structured basis for cross-city comparison.

Table 1: Comparative Statistics of Waste and Circular Economy Practices in UK Cities (GOV.UK, 2024)

City	Annual Waste Approx	Household Share	Recycling Rate (Current)	Policy / Targets	Circular Economy Programs & Innovations	Key Challenges
London	7+ million tons	~50% (~3.5M tons)	Wide variation: <20% (inner-city) to >40% (suburbs)	Target: 65% recycling, zero biodegradable/recyclables to landfill by 2026	ReLondon partnership, food waste minimization, anaerobic digestion plants, digital tracking & waste exchange pilots	Socio-economic and infrastructural inequalities; uneven recycling distribution
Bristol	~0.2–0.3M tons* (est.)	Majority household	~45–50% (higher than UK average)	Green Capital Award 2015, strong local commitments	Smart bin tech, route optimization, citizen engagement, bottom-up initiatives	Scaling grassroots initiatives; maintaining citizen engagement
Manchester	1.1M tons household	100% of figure	~45% recycling (Kerbside system)	Greater Manchester Combined Authority model	Large-scale infrastructure, reuse shops, digital recycling engagement	Managing bulk waste volume; balancing centralized and local initiatives

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Glasgow	~0.9–1.0M tons* (est.)	Majority household	~25% (well below Scottish avg. ~45–50%)	Circular Economy Route Map (2020–2030); Zero Waste Scotland	Circular food system strategy, reuse hubs, CE incubators	Low citizen participation; high-density housing limits Kerbside recycling
Cardiff	~0.4–0.5M tons* (est.)	Majority household	>60% (among Europe's best)	Towards Zero Waste (Welsh Gov. strategy); >70% national targets by 2025	Kerbside-sort collection, high-quality recycling streams	Maintaining high performance; scaling for future population growth

Figure 4: Recycling Rate vs Policy Targets in UK Cities

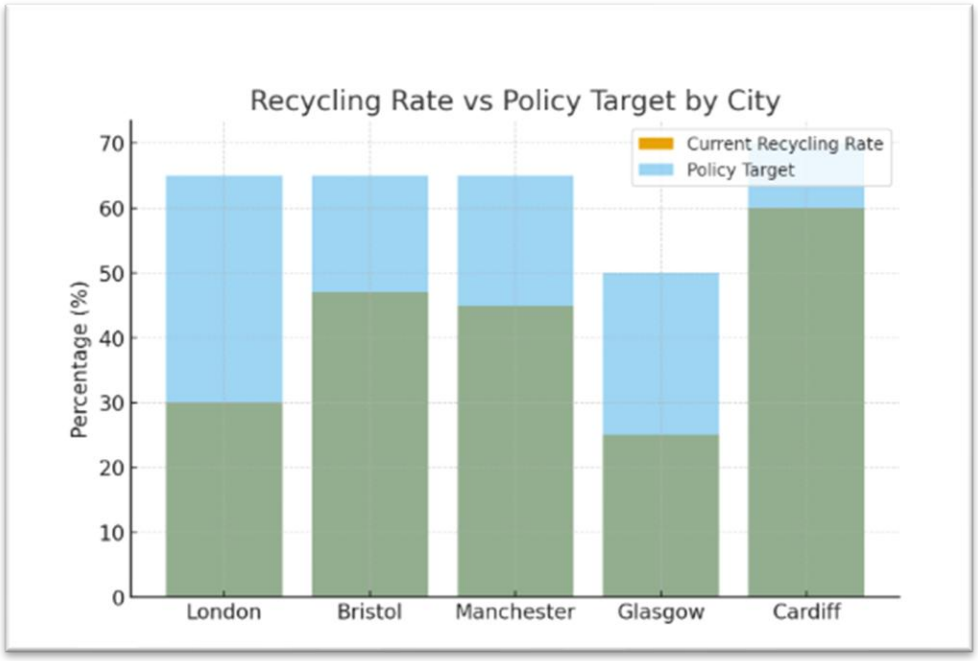
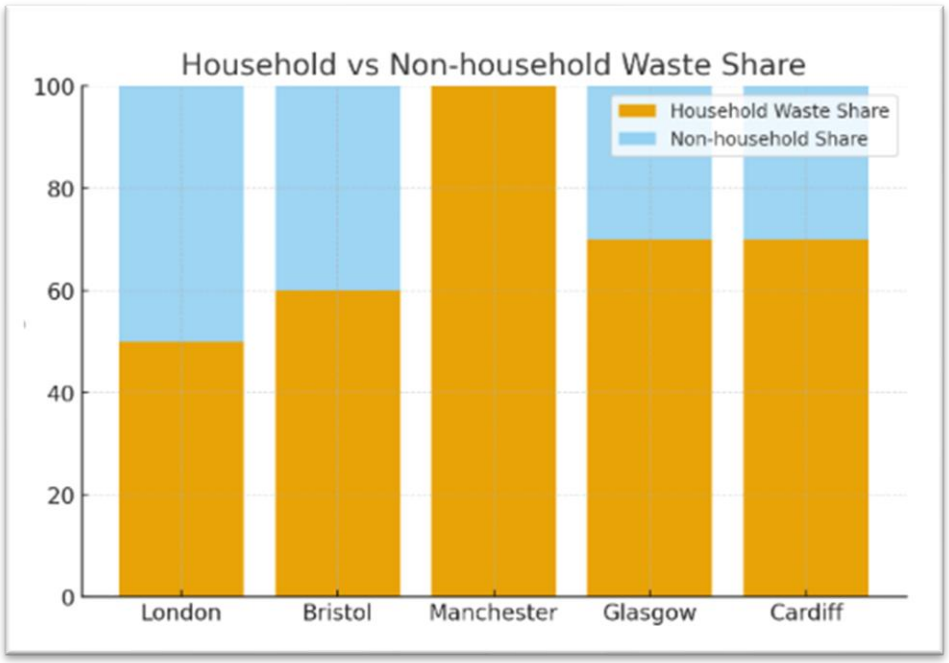


Figure 5: Household vs Non-household Waste Share by City



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UK CITIES AND CE: A CASE STUDY APPROACH

London

In London, the volume of waste produced is regarded to be more than seven million tons each year with household waste that makes nearly half of the total number of waste produced in London. According to the London Environment Strategy (2018), the city has established some standards: the recycling of the volume of municipal waste must reach a new level of 65 percent and the content of biodegradable or recyclable materials in the landfills should become null by the year 2026 (Mayor of London, 2018). In order to fulfill these aspirations, there are different circular economy initiatives that have been developed. The main actor is the London Waste and Recycling Board which has been renamed ReLondon together with the municipalities, businesses, and community organizations to entrench principles of CE across the city (ReLondon, 2025).

Food waste minimization programs and anaerobic digestion plants have also been invested in on a large scale to transform organic waste into renewable energy and soil enhancers (Lambeth, 2023). Besides, London is experimenting with the Virtualized element of the ReSOLVE system by pilot projects, such as the waste exchange and digital tracking. The recycling however does not spread evenly in the city with some of the boroughs in the suburbs recording soaring recycling rates of over 40 percent. Comparatively, the rates in certain inner-city districts are lower than 20 percent, which is caused by social, economic, and infrastructural disparities (R4GM, 2024).

Bristol

The green capital status of Bristol was boosted further as Bristol became the winner of the European Green Capital Award in 2015. The Bristol garbage Company, handling the garbage management in the city is known to be quite creative and also they are involved in the community. The other course of action that Bristol has been testing is the optimization of strategies, including smart bin systems and route optimisation systems, that should improve efficiency in collection services (Cameron, 2024). The decentralised campaigns and citizenship-based participation have been at the centre of Bristol compared to any other city in the UK with regards to its circular transition.

Manchester

The management of the waste in Greater Manchester takes a combined authority model, whereby it processes about 1.1 million tons of household waste annually. The area has made significant investments in bulk infrastructure. While Kerbside recycling systems have been able to guarantee a high rate of capture, reuse shops in household trash recycling centers provide a chance to recover materials and products before disposal (WRAP, 2023). Digital engagement techniques have been used more recently to encourage households to recycle more effectively (Taşeli, 2007).

Glasgow

Being the largest city in Scotland, It has emerged as a center of national ambitions concerning the circular economy. The Change of Direction, the Glasgow Circular Economy Route Map (2020-2030), identifies a decade of planning to include the principles of the CE in planning and economic development strategies of the city. Glasgow has been a city in a sequence of waste programs in keeping with the national policy environment of Scotland, which seeks to reshape infrastructures and urban cultural practices. The city has invested in recycling infrastructure within the Zero Waste Scotland program (OECD, 2021). It is now adopting a circular food system strategy that places importance on the redistribution of surplus food and the valorization of organic waste.

Community reuse hubs and incubators of circular business have also been supported by pilot projects, as part of an attempt to encourage both grassroots and enterprise-led innovation. However, the city of Glasgow's recycling level reaches approximately 25 percent, which is nearly half of the Scottish average waste production. Structural problems, such as high-density houses, add to the concerns of implementing the

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Kerbside collection. There has also been a lack of citizen involvement, and the social aspect of attaining the circular goals is critical (Calisto Friant et al., 2023).

Cardiff

Being one of the pioneering municipal waste management authorities and has recorded consistently high household recycling rates of over 60 percent- one of the best in Europe (see figure 5). The city has enjoyed the high policy framework of the devolved Welsh Government, especially the Towards Zero Waste strategy with its high national reuse and recycling targets (Liywodraeth Cymru Welsh Government, 2015). Cardiff has a Kerbside-sort collection service where materials are sorted at home so that the end product recycled is of high quality and contamination is limited.

This blend of technological, policy, and cultural elements shows how a progressive devolved government may enable local commitment to produce world-class outcomes (CARDIFF News Room, 2025).

METHODS

Research Design and Approach

This study adopted a qualitative comparative case study design to examine how circular economy (CE) principles are implemented within municipal waste management systems across selected UK cities. A comparative case study approach was considered appropriate because it enables the exploration of similarities and differences across multiple cases operating within distinct governance, policy, and infrastructural contexts (Yin, 2018). The study focused on five cities—London, Bristol, Manchester, Glasgow, and Cardiff—which were selected due to their differing approaches to waste management, governance arrangements, and circular economy initiatives. The research was guided by a pragmatic interpretivist perspective, recognising that circular economy implementation is shaped by institutional arrangements, policy environments, stakeholder interactions, and local socio-economic conditions. Rather than seeking universal causal relationships, the study aimed to develop a contextual understanding of how municipal authorities interpret and operationalise circular economy principles within their waste management systems.

Case Selection and Data Collection

A purposive sampling strategy was employed to select the five case study cities. The selected cities represent diverse geographical locations, governance structures, population characteristics, and levels of circular economy development within the United Kingdom. London was selected because of its scale and ambitious circular economy policies; Bristol because of its strong community-based sustainability initiatives; Manchester due to its regional governance structure and extensive waste infrastructure; Glasgow because of Scotland's evolving circular economy policy framework; and Cardiff because of Wales' internationally recognised recycling performance. Data collection was based exclusively on secondary sources. A systematic document search was undertaken between January and June 2025 using academic databases, government repositories, municipal reports, and policy documents. Sources included Scopus, Web of Science, Google Scholar, OECD iLibrary, GOV.UK, DEFRA publications, devolved government reports, municipal waste strategies, and circular economy policy documents.

The document search utilised combinations of key terms including “circular economy”, “municipal waste management”, “ReSOLVE framework”, “urban sustainability”, and the names of the selected cities. To ensure relevance and consistency, only documents published between 2015 and 2025 were considered.

Documents were included if they:

1. Addressed circular economy or municipal waste management at national, regional, or municipal levels;
2. Were produced by government agencies, municipal authorities, recognised organisations, or peer-reviewed academic sources;

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3. Contained empirical evidence, policy information, performance data, or conceptual discussion relevant to circular economy implementation.

The initial search identified 82 potentially relevant documents. Following screening for relevance, duplication, credibility, and alignment with the study objectives, 42 documents were retained for detailed analysis.

Data Analysis and Codin

Data were analysed using thematic analysis guided by the ReSOLVE framework developed by the Ellen MacArthur Foundation (2015). The framework provided a structured analytical lens for assessing the extent to which municipal waste management systems reflected six core circular economy dimensions: Regenerate, Share, Optimise, Loop, Virtualise, and Exchange. All selected documents were imported into NVivo 14 to facilitate systematic coding and organisation of qualitative data. A deductive coding approach was initially employed using the six ReSOLVE dimensions as primary coding categories.

Six major code categories were defined deductively, corresponding to the ReSOLVE dimensions, with subcodes tailored to municipal CE activities:

ReSOLVE Dimension	Coding Indicators
Regenerate	Use of renewable/biological resources, composting, anaerobic digestion, and low-carbon energy systems
Share	Repair cafés, reuse shops, sharing platforms, and community-driven waste reduction
Optimize	Smart bin technologies, route optimization, process efficiency, data-led monitoring
Loop	Closed-loop recycling, materials recovery, and waste diversion
Virtualize	Digital tracking, waste data exchange systems, online citizen engagement
Exchange	Replacement of linear practices with circular innovations, such as green procurement, alternative materials, circular business models, and resource recovery technologies.

During the coding process, additional sub-themes emerged relating to governance capacity, infrastructure development, public participation, digital innovation, policy support, and financial mechanisms. Text segments were coded according to their relevance to one or more ReSOLVE dimensions. Where evidence reflected multiple aspects of circular economy implementation, overlapping codes were applied. For example, initiatives involving digital waste tracking and service efficiency were coded under both Virtualise and Optimise. This approach allowed for a more comprehensive assessment of the interconnected nature of circular economy practices within municipal systems. Following coding, thematic summaries were developed for each city. The results were then synthesised through cross-case comparison to identify common patterns, distinctive practices, implementation barriers, and enabling factors. Particular attention was given to variations in governance arrangements, infrastructure provision, public engagement, and policy environments across the five case studies.

Reliability and Trustworthiness

Several measures were adopted to enhance the trustworthiness of the analysis. First, data triangulation was achieved through the use of multiple source types, including government publications, municipal reports, policy documents, and peer-reviewed literature. Second, coding procedures were applied consistently across all case studies using a predefined analytical framework. Third, approximately 20% of the coded material was independently reviewed to assess consistency in interpretation and category allocation. Any differences in coding were discussed and resolved through iterative review. The study also maintained transparency by documenting search procedures, inclusion criteria, coding decisions, and analytical processes. These measures contribute to the credibility, dependability, and confirmability of the findings (Lincoln & Guba, 1985).

Limitations

Several limitations should be acknowledged. First, the study relied exclusively on secondary data and therefore reflects information reported within published documents rather than direct stakeholder experiences. Second,

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differences in reporting practices across cities may have influenced the availability and comparability of data. Third, the analysis focused on five major UK cities and therefore may not fully represent circular economy implementation in smaller municipalities or rural areas. Despite these limitations, the comparative approach provides valuable insights into how circular economy principles are operationalised within different municipal waste management contexts and offers a robust foundation for cross-city analysis using the ReSOLVE framework.

RESULTS

The comparison of London, Bristol, Manchester, Glasgow, and Cardiff cities reveals how these cities are integrating circular economy (CE) policies into their municipal waste systems, as detailed in the table below.

Table 2: Thematic qualitative analysis table mapping the five selected UK cities (London, Bristol, Manchester, Glasgow, Cardiff) against the main themes that emerged from case study data

Theme	London	Bristol	Manchester	Glasgow	Cardiff
Governance & Institutional Capacity	Strong institutional body (ReLondon, 2025) fosters CE partnerships, but governance fragmented across boroughs.	Municipal company (bristol.gov.uk, 2025) with strong community ties; governance relatively cohesive.	Managed at combined authority level; coordinated but constrained by legacy infrastructure contracts.	Supported by Scottish Government but weak local participation undermines progress.	Strong alignment with devolved Welsh Government; clear national–local coordination ensures consistency.
Infrastructure Pathways & Lock-in	Mixed infrastructure; borough disparities in capacity; pilots in anaerobic digestion.	Prioritized household food waste collection and AD; infrastructure supports higher-order CE.	Heavy investment in energy-from-waste and MBT has locked system into incineration dependence.	Recycling investments under Zero Waste Scotland; limited by housing constraints.	Kerbside-sort and AD facilities enable high-quality recyclates; infrastructure choices align with CE.
Public Engagement & Social Innovation	Uneven recycling participation; inner-city boroughs below 20% vs. suburban above 40%.	Strong grassroots-led repair cafés, reuse shops, and sharing schemes; high citizen engagement.	Public engagement improving through digital trials, but reuse culture less embedded.	Citizen participation weak; high-density housing limits Kerbside engagement.	Strong public campaigns link recycling to Welsh pride and identity; high citizen buy-in.
Digitalization & Optimization	Leading in Virtualize pilots (waste tracking, exchange platforms).	Smart bins and route optimization pilots tested; integration still limited.	Trials of digital engagement tools; potential but underdeveloped.	Limited evidence of digitalization pilots; still reliant on traditional systems.	Some optimization in collection; focus remains on consistency and Kerbside separation.
Policy Context & Devolution	Governed under England's Resources & Waste Strategy (2018); borough autonomy creates variation.	Benefits from England's strategy but shaped more by city-led innovation and recognition: Green Capital	Governed under England's framework; regional combined authority provides partial coherence.	Supported by Scotland's CE Bill (2023) and Route Map; policy support strong but delivery uneven.	Benefits from Towards Zero Waste (2010); one of Europe's most coherent policy contexts.
Finance & Economic	ReLondon facilitates	Municipal funding directed into	Large sunk costs in incineration	Funding through Zero Waste	Stable funding from devolved

Enablers	partnerships and investments; financial disparities between boroughs persist.	innovation; partnerships with community actors leverage resources.	restrict financial flexibility for alternative CE measures.	Scotland; challenges in sustaining local-level financing for participation schemes.	government; strong integration of EPR and Kerbside-sort reduces costs long term.

DISCUSSION

Governance as a Determinant of Circular Economy Performance

The findings indicate that governance arrangements play a fundamental role in determining the effectiveness of circular economy (CE) implementation within municipal waste management systems. Across the five case-study cities, those with stronger institutional coordination and clearer policy alignment generally demonstrated more balanced circular economy outcomes. Cardiff emerged as the strongest example of governance coherence, benefiting from close alignment between local authorities and the Welsh Government's long-term waste strategy. This coordinated approach has enabled consistent implementation of waste reduction, recycling, and resource recovery initiatives. Similarly, Bristol's municipally led waste management model has facilitated collaboration between local authorities, community organisations, and residents, creating favourable conditions for innovation and citizen participation.

By contrast, London's governance structure presents challenges despite ambitious circular economy aspirations. While ReLondon provides strategic leadership and facilitates partnerships across sectors, the autonomy of individual boroughs results in variations in service delivery and recycling performance. Manchester benefits from a combined authority structure that promotes regional coordination; however, historical infrastructure commitments limit policy flexibility. Glasgow demonstrates strong national policy support through Scotland's circular economy agenda, but implementation at the local level remains uneven. These findings support previous research suggesting that governance coherence, institutional capacity, and effective stakeholder collaboration are essential prerequisites for successful circular economy transitions (Martin et al., 2024).

Infrastructure Pathways and Technological Lock-In

The comparative analysis highlights the importance of infrastructure in shaping municipal circular economy pathways. Infrastructure investments influence not only current waste management performance but also future opportunities for circularity. Cardiff and Bristol have invested in systems that support higher-order circular economy activities, including food waste collection, anaerobic digestion facilities, and efficient kerbside sorting systems. These investments facilitate material recovery while reducing contamination and improving resource efficiency.

Manchester presents a contrasting example. Although the city has achieved substantial landfill diversion, significant investment in mechanical biological treatment and energy-from-waste infrastructure has created a degree of technological lock-in. Such investments can limit flexibility and reduce incentives to prioritise waste prevention, reuse, and repair strategies. Similar concerns have been identified within the wider circular economy literature, where long-term dependence on disposal-oriented infrastructure may constrain more regenerative approaches to resource management (Malinauskaite & Jouhara, 2017).

London's infrastructure landscape remains uneven due to variations in borough-level capacity and investment, while Glasgow continues to face operational challenges associated with high-density housing and collection logistics. These findings demonstrate that infrastructure decisions have long-term implications for circular economy performance and should therefore be considered within broader strategic planning processes.

Public Engagement and Social Innovation

The findings demonstrate that citizen participation represents a critical component of successful circular economy implementation. Cities characterised by strong public engagement generally performed better across

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue VI June 2026

several dimensions of circularity, particularly those related to reuse, sharing, and waste reduction. Bristol provides a notable example through its extensive network of repair cafés, reuse centres, and community-led sharing initiatives. These activities contribute not only to waste prevention but also to social cohesion and community resilience.

Cardiff similarly benefits from high levels of public participation, supported by sustained awareness campaigns that position recycling and waste reduction as elements of civic responsibility. The city's success suggests that behavioural change initiatives can complement infrastructural investments and policy interventions to improve circular economy outcomes.

Conversely, lower levels of participation in Glasgow and some London boroughs were associated with weaker performance in several areas of municipal waste management. Structural barriers, including housing density and socio-economic disparities, appear to influence engagement levels and access to recycling services. These findings reinforce the growing body of literature that emphasises the social dimensions of circular economy transitions and highlights the importance of public involvement alongside technological and policy innovations (Calisto Friant et al., 2023).

Digitalisation and Emerging Opportunities for Circular Economy Innovation

Digital technologies are increasingly recognised as important enablers of circular economy implementation. The findings reveal substantial variation in the adoption of digital solutions across the five cities. London demonstrates the most advanced application of digital technologies through initiatives involving waste tracking systems, resource exchange platforms, and data-driven service optimisation. The effectiveness of such digital waste management systems depends on the quality of data monitoring and anomaly detection capabilities. Advanced artificial intelligence techniques can enhance system responsiveness by automatically identifying unusual operational patterns and generating adaptive monitoring rules, thereby strengthening the reliability of digital resource management platforms (Durodola, 2025). These innovations have the potential to improve operational efficiency, increase transparency, and support more informed decision-making. The growing role of digital technologies in circular economy implementation is consistent with findings from other sectors, where artificial intelligence has been shown to improve transparency, traceability, operational efficiency, and real-time decision-making through enhanced data visibility and monitoring systems (Ogar, 2025). Bristol and Manchester have also begun experimenting with digital tools, including smart bins and digital engagement platforms, although these initiatives remain relatively limited in scale. Glasgow exhibits little evidence of widespread digital innovation within municipal waste management, while Cardiff has prioritised operational consistency and behavioural interventions over technological transformation. The uneven adoption of digital technologies suggests that differences in financial resources, institutional capacity, and strategic priorities continue to influence innovation pathways. As cities seek to improve resource efficiency and service delivery, digitalisation is likely to become an increasingly important component of municipal circular economy strategies.

ReSOLVE Framework Performance across the Five Cities

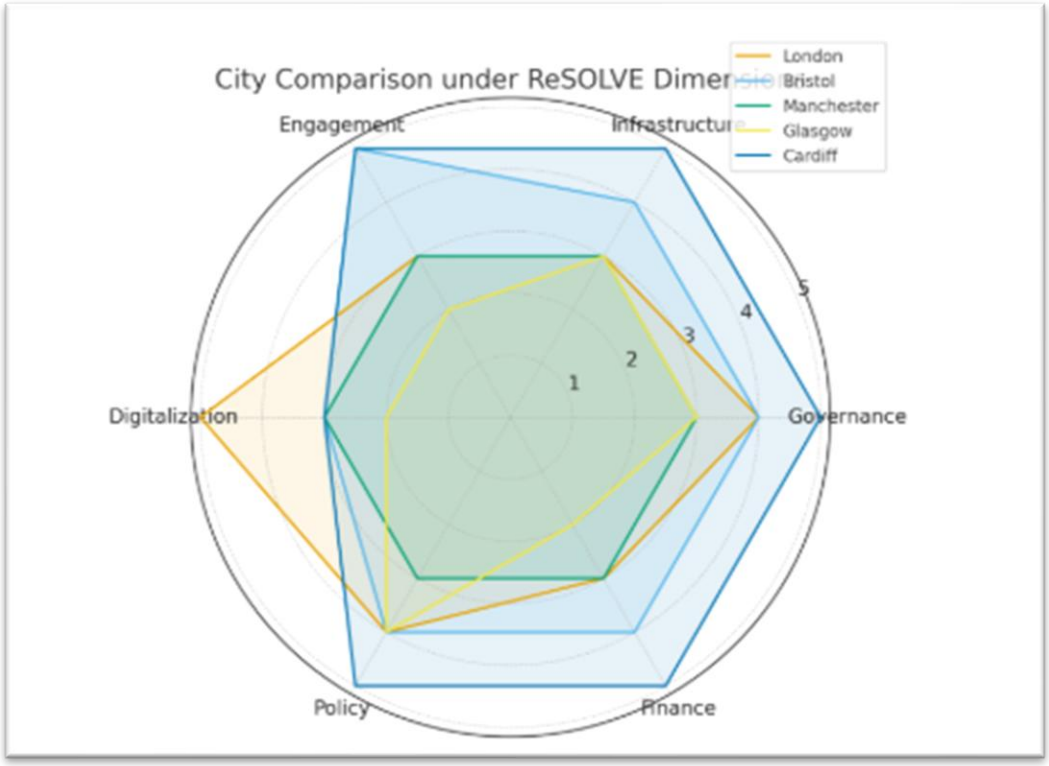
The application of the ReSOLVE framework provides a comprehensive perspective on how circular economy principles are operationalised within municipal waste systems. Figure 6 presents a comparative assessment of the five cities across the six dimensions of the framework: Regenerate, Share, Optimise, Loop, Virtualise, and Exchange. Rather than focusing solely on recycling performance, the framework highlights broader patterns of resource recovery, innovation, citizen participation, and system efficiency.

Table 3: Comparative Assessment of ReSOLVE Framework Performance Across Selected UK Cities

City	Regenerate	Share	Optimise	Loop	Virtualise	Exchange
London	Medium	Medium	High	High	High	High
Bristol	High	High	High	High	Medium	Medium
Manchester	Medium	Medium	Medium	High	Medium	Medium
Glasgow	Medium	Low	Medium	Medium	Low	Medium
Cardiff	High	High	High	High	Medium	Medium

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue VI June 2026

Figure 6: Comparative ReSOLVE Dimension Performance of UK Cities



The Regenerate dimension highlights the importance of biological resource recovery and waste prevention strategies. Cardiff and Bristol demonstrate particularly strong performance through investments in anaerobic digestion, food waste collection, and reuse initiatives that reduce reliance on disposal routes. Manchester's continued dependence on energy-from-waste infrastructure limits opportunities for more regenerative approaches despite high landfill diversion rates. London and Glasgow have made progress through investments in recycling and organic waste treatment but continue to face implementation challenges that constrain overall performance.

Within the Share dimension, Bristol and Cardiff again emerge as leading examples due to the strength of their repair networks, reuse programmes, and community engagement initiatives. These activities extend product lifespans, reduce waste generation, and encourage behavioural change. London displays significant variation between boroughs, while Manchester and Glasgow continue to develop stronger cultures of reuse and sharing.

Performance in the Optimise and Loop dimensions reflects differences in operational efficiency and material recovery systems. Cardiff's kerbside-sort approach produces high-quality recyclates with low contamination rates, while Bristol's infrastructure supports effective resource recovery. London's performance is strengthened by digital innovation and ambitious policy targets, although borough-level disparities remain evident. Manchester's infrastructure enables high levels of waste capture but continues to prioritise recovery over reuse, while Glasgow faces practical challenges associated with collection systems and housing density.

The Virtualise and Exchange dimensions remain comparatively underdeveloped across all five cities. London demonstrates the most significant progress through digital waste tracking systems, exchange platforms, and innovation-focused initiatives. Bristol and Manchester have begun integrating digital technologies into waste management practices but have yet to achieve widespread implementation. Glasgow's Circular Glasgow Network illustrates progress in business-oriented circular innovation, while Cardiff has focused primarily on behavioural and service-based improvements. Overall, the findings suggest that digitalisation and innovation remain areas of considerable opportunity for future municipal circular economy development.

Taken together, the ReSOLVE analysis indicates that Cardiff and Bristol exhibit the most balanced implementation of circular economy principles across all six dimensions. London demonstrates strengths in

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue VI June 2026

innovation and strategic ambition but remains constrained by governance fragmentation. Manchester's performance is influenced by infrastructure lock-in, while Glasgow faces challenges associated with participation and implementation. These findings reinforce the importance of adopting integrated approaches that combine governance, infrastructure, finance, technology, and citizen engagement.

Policy and Practical Implications

The findings have several implications for policymakers and municipal authorities seeking to accelerate circular economy transitions. First, governance coherence appears to be a critical enabling factor, suggesting that stronger coordination between national, regional, and local actors may improve implementation outcomes. Second, infrastructure investments should prioritise resource recovery, reuse, and waste prevention pathways rather than creating long-term dependency on treatment technologies that limit future flexibility. Third, public engagement should be viewed as a strategic component of circular economy policy rather than a supplementary activity. Finally, greater investment in digital technologies and innovation platforms may help cities improve efficiency, transparency, and resource management performance.

The study further demonstrates the value of applying the ReSOLVE framework as a tool for evaluating municipal circular economy performance. By moving beyond traditional recycling metrics, the framework provides a more holistic understanding of how cities create, retain, and recover value from resources. This broader perspective is particularly important for policymakers seeking to design integrated strategies capable of delivering long-term environmental, economic, and social benefits.

CONCLUSION

This study examined the implementation of circular economy (CE) principles within municipal waste management systems across five UK cities: London, Bristol, Manchester, Glasgow, and Cardiff using the ReSOLVE framework as an analytical lens. Through a comparative qualitative analysis of policy documents, municipal strategies, and secondary data sources, the study explored how governance arrangements, infrastructure pathways, citizen participation, digital innovation, and financial mechanisms influence the transition towards more circular waste management systems. The findings reveal substantial variation in the extent to which circular economy principles have been embedded within municipal waste practices. Cardiff and Bristol emerged as the strongest performers, demonstrating relatively balanced implementation across the six ReSOLVE dimensions. Their success is supported by coherent governance structures, sustained public engagement, investment in resource recovery infrastructure, and strong policy alignment. London exhibited notable strengths in innovation, digitalisation, and strategic ambition but continues to face challenges associated with governance fragmentation and uneven implementation across boroughs. Manchester's progress is constrained by infrastructure lock-in resulting from significant investment in energy-from-waste facilities, while Glasgow faces ongoing challenges related to citizen participation, housing constraints, and operational delivery.

A key contribution of this study is the application of the ReSOLVE framework to municipal waste management at the city level. Unlike approaches that focus primarily on recycling rates or landfill diversion, the framework enabled a broader assessment of circular economy performance across multiple dimensions, including regeneration, sharing, optimisation, material looping, digitalisation, and innovation. The findings demonstrate that successful circular economy transitions depend not on excellence in a single area but on the alignment of governance, infrastructure, finance, technology, and citizen engagement. The study further highlights that municipal circular economy implementation is influenced by contextual factors that extend beyond technical waste management solutions. Effective transitions require long-term policy consistency, institutional collaboration, financial flexibility, and active public participation. Cities that successfully integrate these elements are better positioned to move beyond traditional waste management approaches towards more regenerative and resource-efficient systems.

As the United Kingdom continues to pursue circular economy objectives and net-zero commitments, municipal authorities will play an increasingly important role in translating national ambitions into practical outcomes. Strengthening collaboration between governments, communities, and industry while investing in innovative

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue VI June 2026

and inclusive circular economy initiatives will be essential for achieving sustainable resource management and supporting the transition to a more circular future.

Policy Recommendations

The findings of this study suggest several policy measures that could strengthen the implementation of circular economy principles within municipal waste management systems across the United Kingdom. First, greater coordination between national, devolved, and local governments is required to ensure consistency in circular economy objectives while allowing flexibility for local innovation. The experiences of Cardiff and Bristol demonstrate that policy coherence and institutional alignment can support more effective implementation of circular economy strategies. Second, investment should increasingly prioritise waste prevention, reuse, repair, and resource recovery infrastructure rather than long-term dependence on treatment technologies that may constrain future circularity. Cities should be encouraged to expand initiatives such as kerbside-sort collection systems, reuse centres, repair programmes, and anaerobic digestion facilities. Third, digital technologies should be more widely integrated into municipal waste management systems. Smart waste monitoring, digital tracking platforms, and data-driven optimisation tools have the potential to improve operational efficiency, increase transparency, and support evidence-based decision-making. Fourth, local authorities should strengthen public engagement programmes that encourage behavioural change and community participation. The success of Bristol's community-led initiatives and Cardiff's public awareness campaigns demonstrates the importance of citizen involvement in achieving circular economy objectives. Finally, the establishment of a national municipal circular economy knowledge-sharing network could facilitate the exchange of best practices between cities, enabling local authorities to learn from successful approaches and accelerate innovation across the sector.

Study Limitations

Several limitations should be considered when interpreting the findings of this study. The research adopted a qualitative comparative case-study approach based primarily on secondary data sources. Although this approach enabled a detailed examination of policy frameworks and municipal strategies, it did not include primary data collection from stakeholders such as local authority officials, waste management practitioners, community organisations, or residents. Furthermore, the study focused on five major UK cities between 2015 and 2025. While these cities provide valuable insights into municipal circular economy implementation, the findings may not be fully representative of smaller towns, rural authorities, or other international contexts where governance structures, infrastructure capacity, and socio-economic conditions differ significantly. Also, the assessment relied on publicly available documents and reports, which may reflect policy intentions more strongly than actual implementation outcomes. Consequently, some differences may exist between reported strategies and operational performance on the ground. Despite these limitations, the study provides a robust comparative assessment of how circular economy principles are being applied within diverse municipal waste management contexts across the United Kingdom.

Future Research Directions

This study identifies several opportunities for future research:

1. Longitudinal studies could examine how municipal circular economy performance evolves over time, particularly in response to emerging policies, technological developments, and changing environmental targets.
2. Future research could incorporate primary data collection through interviews, surveys, and stakeholder workshops to explore the perspectives of policymakers, waste management professionals, community organisations, and residents. Such approaches would provide deeper insights into the practical challenges and opportunities associated with circular economy implementation.
3. Comparative international studies could benchmark UK cities against leading circular economy initiatives in Europe and other regions, helping to identify transferable best practices and innovative policy approaches.

4. Further research is needed to evaluate the economic implications of different waste management pathways, including the costs and benefits of transitioning from infrastructure-dependent systems towards more regenerative and resource-efficient models.
5. Future studies should explore the role of emerging digital technologies, including artificial intelligence, smart monitoring systems, and digital material exchange platforms, in supporting municipal circular economy transitions. Particular attention should also be given to issues of equity and environmental justice to ensure that the benefits of circular economy initiatives are distributed fairly across different communities and social groups.

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