

Review

Integrating Circular Economy Principles into Urban Mobility for Smart City Transportation: A Literature-Grounded Review

Anna Granà ^{1,*} , Elżbieta Macioszek ^{2,*}  and Maria Luisa Tumminello ¹

¹ Department of Engineering, University of Palermo, Viale delle Scienze ed 8, 90128 Palermo, Italy; marialuisa.tumminello01@unipa.it

² Department of Transport Systems, Traffic Engineering and Logistics, Faculty of Transport and Aviation Engineering, Silesian University of Technology, Krasińskiego 8 Street, 40-019 Katowice, Poland

* Correspondence: anna.grana@unipa.it (A.G.); elzbieta.macioszek@polsl.pl (E.M.)

Abstract

This paper develops a literature-grounded review on connecting circular economy (CE) principles and urban mobility to examine how smart city transportation can be reshaped through durable design, reuse, service-based models, and materials stewardship. A structured review of indexed documents (2010–April 2026) from Scopus and Web of Science identified a set of papers that were screened, thematically grouped into six clusters (design, digital infrastructures, shared mobility, materials management, social inclusion, decision support), and synthesized via textual analysis to generate an integrative, evidence-based conceptual framework, identify empirical and methodological gaps, and propose policy-relevant research priorities informed by the identified topics. The literature documents CE interventions and analytical methods that can lower embodied impacts, raise asset utilization, and recover secondary materials when backed by clear public policies, coordinated governance, and digital platforms. Key limitations include fragmented governance, optimistic recovery rate assumptions, limited integration of life cycle analyses, and weak empirical evidence linking participatory processes to measurable outcomes. The findings are relevant to researchers, planners, policymakers, and practitioners, and indicate that operationalizing circular approaches in urban mobility requires cross-sectoral policy alignment, data governance, financing reform, inclusive stakeholder engagement, interoperable platforms, and longitudinal place-based pilots with multi-metric monitoring aligned with the Sustainable Development Goals.

Keywords: urban mobility; smart cities; circular economy; sustainable transportation; urban metabolism; sustainability transition; life cycle thinking; citizen engagement; social impact



Academic Editor: Marilisa Botte

Received: 27 June 2026

Revised: 15 July 2026

Accepted: 17 July 2026

Published: 19 July 2026

Copyright: © 2026 by the authors.

Licensee MDPI, Basel, Switzerland.

This article is an open access article distributed under the terms and conditions of the [Creative Commons Attribution \(CC BY\)](https://creativecommons.org/licenses/by/4.0/) license.

1. Introduction

Urban transport infrastructure is essential for addressing residents' digital and material needs, but growing social and spatial inequality, high transport costs, inadequately maintained infrastructure, traffic congestion, limited transit options, and physical, regulatory, or socio-economic barriers, compounded by rising living costs, weaken city resilience to climate, geopolitical, and energy crises [1]. Many city and community efforts to create sustainable public spaces still overlook neighborhood-level regenerative, equitable, and social strategies that could transform mobility in smart city transportation [2]. Rapid ur-

banization has created mobility challenges that undermine environmental sustainability, social equity, and economic efficiency.

The integration of circular economy (CE) principles—a systemic model that keeps products and materials in use and eliminates waste—into urban transport planning and smart mobility technologies can address these issues by promoting resource-efficient, inclusive, and adaptive transportation solutions [3,4]. Cities represent roughly 70% of global greenhouse gas (GHG) emissions on a consumption-accounting basis; with transportation a major contributor, developing sustainable urban transport systems is therefore a pressing priority [5]. The CE model offers a design-led, systemic approach to these challenges, aiming to eliminate waste and pollution, keep products and materials circulating at high value, and restore natural systems [4]. By decoupling economic growth from use of finite resources, CE helps address climate change and related issues such as biodiversity loss, pollution, and waste [6], and shifts value chains toward restorative practices that keep materials and products in use, design out pollution, and support natural regeneration [7]. Applied to urban mobility, explicitly addressing the movement of people or goods within urban and metropolitan contexts, circular principles lead to concrete strategies: shared services and integrated public transit reduce vehicle ownership and idle capacity; Product-as-a-Service (PaaS) and Mobility-as-a-Service (MaaS) favor access over ownership to optimize fleets and life cycles; closed-loop maintenance, remanufacturing, and recyclable components minimize material loss and support secondary markets; and renewable energy decarbonizes operations, enabling circular energy flows [8,9]. Urban road infrastructure should be planned and designed for full life cycles to extend asset life, support shared mobility, prioritize maintenance, and allow recycling [10,11]. Additional measures include targeted retrofits to extend physical asset life and support multimodal functionality, incentives for durable and repairable design, and data-driven platforms to coordinate demand and fleet use [12,13]. Together, these interventions can increase resilience, reduce environmental impacts, lower life cycle costs, and improve livability [1,13,14]. Implementing circular mobility requires alignment of policies across sectors, stakeholder participation, and metrics focused on outcomes to track material flows, emissions, and social benefits for inclusive, equitable, and scalable transitions [14]. Pilot projects, public–private partnerships, and education campaigns can speed adoption, show citywide scalability, and support long-term monitoring and evaluation [15]. Targeted behavior-change strategies, such as adaptive gamification and immersive simulations for public engagement, can enable modal shifts and wider acceptance, while sustainable business models for mobility services can help scale these strategies by aligning economic, environmental, and social value creation [16–18].

A literature review is needed to consolidate evidence on how CE strategies, including sharing models (such as PaaS and MaaS), regenerative maintenance, renewable energy, and infrastructure planning across the full life cycle, can address the environmental and social challenges of urban mobility, identify gaps in city implementation, and outline future research priorities. However, CE applications have been limited outside industrial settings, highlighting the need for focused, transdisciplinary research in service-oriented domains [19,20]; growing interest in CE as a response to sustainability challenges, together with accelerating urbanization, increase pressure on cities and underscore the need for such research to support equitable, scalable transitions and advance relevant Sustainable Development Goals (SDGs) [20,21].

Aim and Research Questions

The paper presents a literature-grounded review, inductively derived from the examined research corpus, and synthesizes how CE principles are integrated into urban

mobility for smart city transportation. Although sustainable transportation initiatives exist worldwide, CE implementation in smart cities is at an early stage [22,23]. Despite extensive research on smart city sustainability, there is no comprehensive synthesis of how CE principles are applied at the city scale or how advanced technologies for mobility are deployed and evaluated [8,22–24]. In particular, the roles of governance structures and stakeholder engagement in enabling or constraining CE adoption at urban scale are under-explored [8,23]. Although prior studies define and review the CE concept, gaps remain in assessing progress, specifically how urban transportation systems enable circular practices and how the performance, maturity, and impacts of sustainable models are measured in city contexts [9,10,24]. The extent of CE adoption in urban mobility and its practical effectiveness have not been systematically identified and compared across cities and use cases. Therefore, this review synthesizes existing evidence, summarizes achievements and evaluates implications for smart city transportation. By bringing together studies and best practices, it highlights themes and research gaps, compares empirical findings to extract transferable lessons, and offers evidence-based insights for planners and decision-makers to advance sustainable, efficient, and resilient urban mobility. The following research questions (RQs) guided this study, covering infrastructure and services including design of road spaces, management and assessment: RQ1. How can CE principles be operationalized in urban mobility planning at the city level, and how can progress be measured using relevant indicators for sustainable development? RQ2. How can CE requirements be translated into the design and assessment of alternative mobility solutions (services and infrastructure) to improve sustainability, efficiency, and resilience? RQ3. How do the implementation and performance of CE urban mobility initiatives at city and neighborhood scales affect stakeholder engagement, governance arrangements, and digitalization?

Drawing on previous studies and established review typologies [25–27], the authors designed an informed literature review approach with searches in Scopus [28] and Web of Science (WoS) [29] to examine how CE principles can be operationalized in urban mobility for smart city transportation. The two-word expressions “Urban Mobility” and “Circular Economy” were combined in the search; limiting queries to these two strings preserved a broader document corpus and deferred the in-depth examination of their integration and its implications for smart city transportation to the subsequent thematic synthesis phase. Results were limited to peer-reviewed articles published from 2010 to 22 April 2026; duplicates and non-journal items (proceedings, books, editorials) were removed as an intentional scope decision to focus on comparable, peer-reviewed studies and ensure methodological quality and reproducibility. The identified papers were screened, thematically coded into six clusters (Design, Digital Infrastructures, Shared Mobility, Materials Management, Social Inclusion, Decision Support), and synthesized via a detailed full-text analysis which assigned each article one primary topic and one supporting subtopic. This process facilitated information retrieval and helped reduce confirmation bias in topic identification [26,27]. Selection prioritized relevance to the research questions and involved iterative review to extract each study’s core issue, methods, findings, and challenges. As a result, 63 articles focused primarily on urban mobility impacts formed the review’s evidence base, and their contents shaped the review’s direction. The proposed workflow, covering data search, screening, eligibility, and synthesis, supported the development of a conceptual framework for mapping weaknesses and challenges to opportunities and strategies in integrating CE principles into urban mobility planning and smart city transportation.

The review identified empirical and theoretical gaps, outlined methodological pathways for interdisciplinary research, and evaluated policy, governance, and institutional enablers and barriers to CE integration. It also assessed technologies discussed in the literature where they related to CE interventions, and extracted SDG-relevant indicators when

reported. While the findings reflect the authors' methodological choices and interpretations, the study aimed to give built environment stakeholders practical insights to better integrate CE principles and adopt a circular mindset in road design and construction projects. In doing so, the review expanded prior work by applying multi-cluster thematic coding to peer-reviewed studies through April 2026 and directly comparing city- and neighborhood-scale cases to synthesize empirical evidence, governance lessons, and measurable indicators for operationalizing CE in smart city mobility.

The remainder of the paper is organized as follows: Section 2 describes the methodology used to identify and categorize documents; Section 3 presents the conceptual framing of the literature, findings, and research directions toward integration of CE principles and urban mobility for smart city transportation; Section 4 offers discussion, including answers to the core questions; and Section 5 concludes the article.

2. Methodology

The review methodology consisted of four stages: identification and data search, screening, eligibility and thematic structuring, and synthesis and interpretation, each detailed below. After the RQs were defined, the authors selected databases and conducted searches in Scopus [28] and WoS [29], excluding grey literature and manual searches to focus on comparable, peer-reviewed studies and ensure comparability, methodological quality, and reproducibility of results within a homogeneous corpus [8,17,25,26].

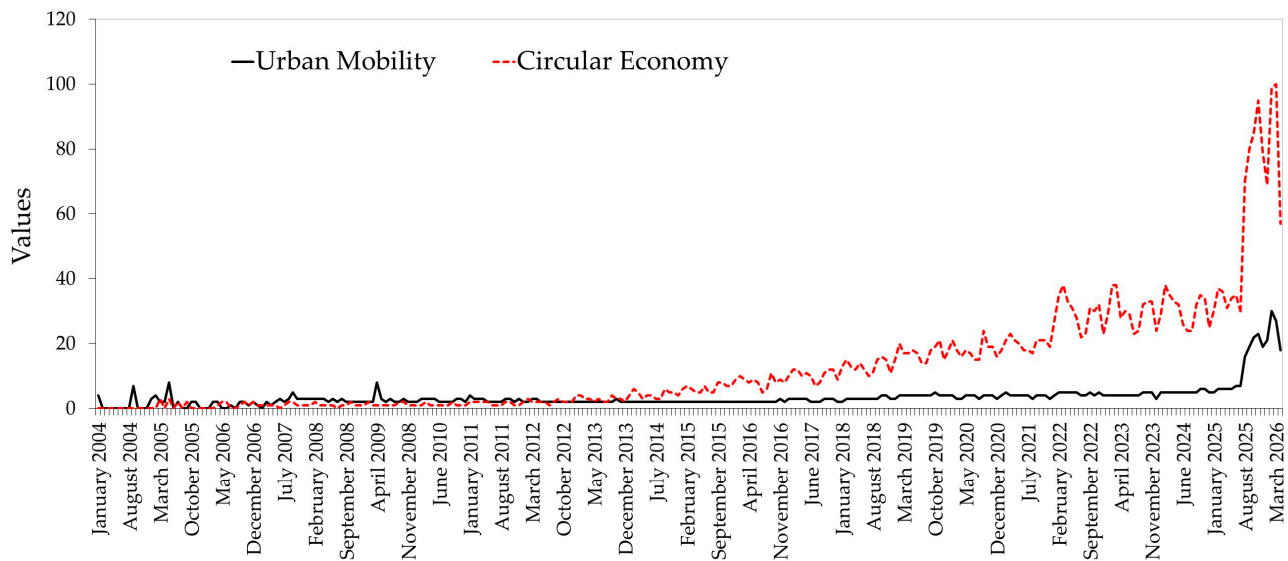
The search combined the key concepts "Urban Mobility" and "Circular Economy" using the Boolean operator AND to ensure retrieved articles addressed both concepts. In Scopus, searches used the Article Title, Abstract, and Keywords (TITLE-ABS-KEY) field; in WoS, the TOPIC field was used. No initial time or language restrictions were applied to capture the evolution of the combined topic. The query TITLE-ABS-KEY("Urban Mobility") AND TITLE-ABS-KEY("Circular Economy") initially returned 127 documents in Scopus, while the fielded search TOPIC("Urban Mobility") AND TOPIC("Circular Economy") returned 97 documents in WoS. Using two search strings ("Circular Economy" and "Urban Mobility") kept the search broad for collecting papers, deferring the evaluation of how CE principles have been integrated into urban mobility and the potential of this integration to the thematic synthesis.

Before screening, results were limited to publications from 2010 through 22 April 2026, reducing Scopus records to 125 while the WoS count remained unchanged. This count did not account for documents indexed in both databases, since some records overlapped. Including studies from the past fifteen years allowed the authors to capture contemporary technological, regulatory, and social developments and to avoid misleading comparisons across periods with different methods or definitions, without overlooking earlier foundational research. Accordingly, Figure 1, covering January 2004 to 22 April 2026, shows rising Google search interest in the terms "Urban Mobility" and "Circular Economy," indicating growing public and professional attention to both topics [30].

After the first step, titles, abstracts, and keywords were screened to remove duplications. Conference proceedings, books and book chapters, and other non-journal items were then excluded, yielding a set of indexed journal articles aligned with the study's objectives and RQs. Review articles and short communications were retained alongside research articles to ensure coverage of research pertinent to the mapped theme. The search returned 64 articles in Scopus and 74 articles in WoS, refining the initial database selection; at this stage, the counts did not yet account for articles indexed in both databases.

Obtaining full texts completed this stage and enabled selection of indexed articles aligned with the research objectives, yielding a refined set to address the RQs. Figure 2 shows indexed documents, including journal articles reported separately, by year for each

database from 2010 through 22 April 2026, for the combined query “Urban Mobility” AND “Circular Economy,” reflecting the growing focus on this research field.



Trends (January 2004–22 April 2026)

Figure 1. Google Trends: Monthly search interest from January 2004 to 22 April 2026 for the query “Urban Mobility” AND “Circular Economy”, created by the authors retrieving data from [30].

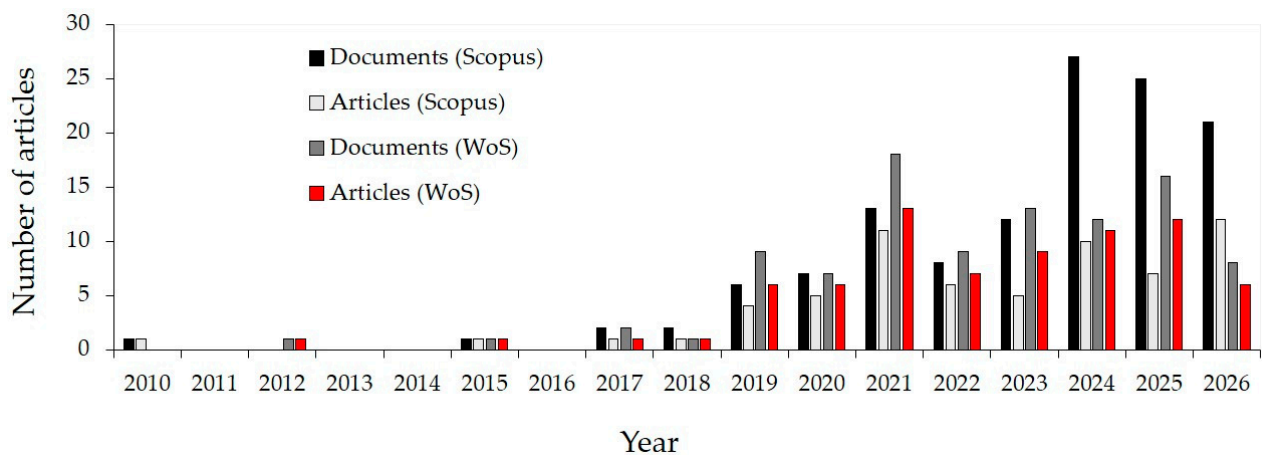


Figure 2. Number of indexed documents and journal articles (2010–22 April 2026), based on the search query “Urban Mobility” AND “Circular Economy”, compiled by the authors using data from [28,29].

The third step involved eligibility and thematic structuring of textual data to develop a conceptual framing of literature. Inclusion required a content-based analysis and study selection was iteratively refined based on each article’s relevance to the investigated joint concepts. Only studies that explicitly linked circularity to urban mobility or demonstrated a clear, direct connection to urban mobility were included; studies focused primarily on industrial implementation, regulatory frameworks, or normative topics were excluded. According to [8–10], urban mobility research was defined as work explicitly addressing the movement of people or goods within urban and metropolitan contexts (modes, services, infrastructure, demand, operations, governance, policy, practices or measurable mobility outcomes), whereas CE-focused studies were defined as those explicitly engaging CE

concepts such as reduce, repair, reuse, remanufacture, recycle, material and resource flows, closed-loop systems, and product–service models.

A bibliometric analysis of the most-cited articles was not conducted because it was deemed to offer limited value for assessing relevance to the study context. The final dataset comprised 63 eligible articles after accounting for articles indexed in both databases: 47 indexed in both, plus 6 found only in WoS and 10 found only in Scopus.

Thematic clustering was used to articulate links between CE principles and urban mobility. From textual analysis, the authors iteratively coded concepts, methods, and findings and grouped related studies until six primary topics (T) emerged, each divided into two inductively derived subtopics (STs), improving retrieval and helping to reduce topic selection bias [26,27]. These six thematic clusters (Design, Digital Infrastructures, Shared Mobility, Materials Management, Social Inclusion, Decision Support), each comprising one primary T and two STs, constituted the review’s background framework. Each article was then assigned to the most relevant T–ST pair to facilitate cross-disciplinary synthesis and practical interpretation, as outlined below:

- Design: (T1) Circular Urban Design and Climate-Responsive Built Environments, which included articles on (ST1a) Circular Design Strategies, Adaptive Reuse, and Neighborhood-Scale Interventions [31–37], and (ST1b) Spatial Planning, Governance Frameworks, and Performance Metrics for Circular Neighborhoods [38–46];
- Digital Infrastructures: (T2) Digital Infrastructures and Data Architectures for Circular Mobility Systems, inclusive of articles on (ST2a) Blockchain-Based Trust, Transparency, and Incentive Mechanisms in Shared Mobility [47–51], and (ST2b) Data Architectures, Platform Ecosystems, and Decision-Support Systems for Integrated Mobility [10,52–57];
- Shared Mobility: (T3) Shared Mobility Systems, Resharing Practices, and Infrastructure Adaptation, which collected articles on (ST3a) Place-Based Resharing Practices, Shared Spaces, and Local Performance Assessment Tools [58–60], and (ST3b) Shared Mobility Operations, Logistics Integration, and Infrastructure Retrofitting Frameworks [61,62];
- Materials Management: (T4) Circular Materials Management and Urban Resource Flows, which gathered articles on (ST4a) Urban Mining and Material Stock Analysis for Mobility Systems [63–67], and (ST4b) Recycling Processes, Remediation Strategies, and Inclusive Circular Supply Chains [68–70];
- Social Inclusion: (T5) Social Inclusion, Governance, and Territorial Value in Circular Transitions, featuring articles on (ST5a) Inclusive Livelihoods, Local Markets, and Place-Based Value Creation [71–73], and (ST5b) Participatory Governance and Policy Frameworks for Equitable Circular Transitions [8,74–80];
- Decision Support: (T6) Analytical Methods, Systems Thinking and Decision Support for Urban Mobility containing articles on (ST6a) Decision Support and Assessment Methods for Circular Mobility Strategies [81–84], and (ST6b) Use Infrastructures, Causal Loop Analysis, and Scenario and Spatial Flow Assessment [85–91].

While these identifications and assignments were not exhaustive, they reflected the authors’ judgments in organizing the reviewed literature. The resulting T and ST structure supported cross-topic synthesis, helped prioritize interdisciplinary research and place-based circular innovations, and informed a literature-based conceptual framework to support integration of CE principles into urban mobility within smart city transportation. Although thematic overlap could occur due to shared terminology or approaches, articles were assigned to topics based on their predominant relevance.

The fourth step involved synthesis to produce the literature review. Key information was systematically extracted from each study, with core issues, methods, findings, and challenges summarized in tables by paper. Narrative and thematic synthesis was then

developed to identify recurring patterns and research gaps across the investigated literature. The interpretation was inherently analytical and reflected the authors' coding and evaluative decisions. The review, limited to articles indexed in Scopus from 2010–mid-2026, offers a broad multidisciplinary synthesis rather than deep technical or context-specific analysis. Both databases index peer-reviewed literature and provide baseline quality filtering. Thematic grouping into T and STs involved subjective judgment that may have affected interpretation, but the selection focused on studies addressing the joint search theme and provides useful insights for integrating CE principles into urban mobility for smart city transportation. Figure 3 presents the research workflow; the findings in relation to the RQs, emphasizing implications for urban mobility, CE transitions, and smart city policymaking, are discussed in Section 4; and future directions are outlined in Section 5.

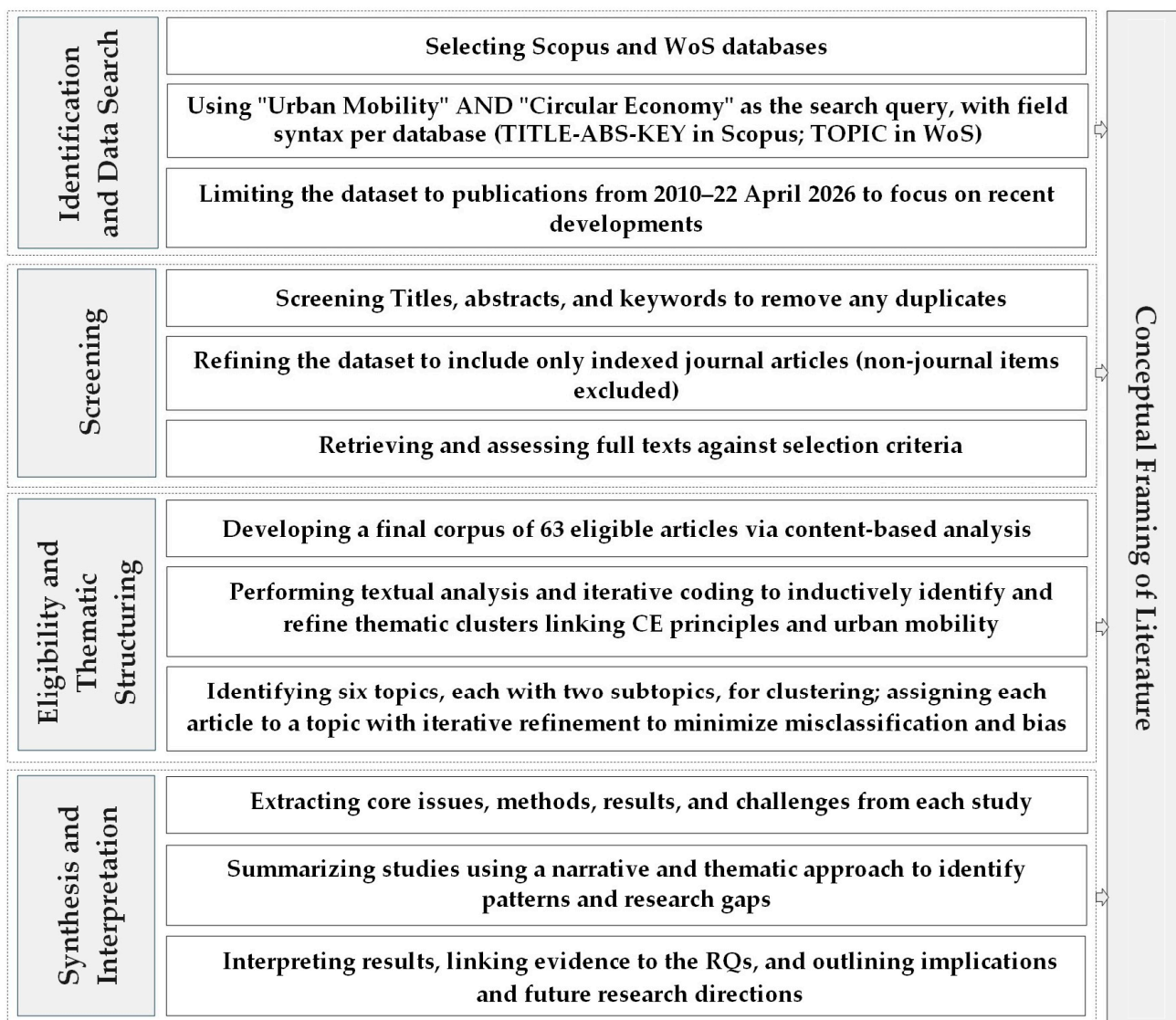


Figure 3. The four-step workflow designed for reviewing the investigated papers.

3. Literature Review and Conceptual Framing

This section presents the literature review based on a textual analysis of the articles associated with Ts and STs. Figure 4 visualizes the review structure, summarizing Ts and STs to support comparative synthesis and practical application. Tables 1–6 are organized by core issue, methodology, results, and challenges for paper-by-paper analyses.

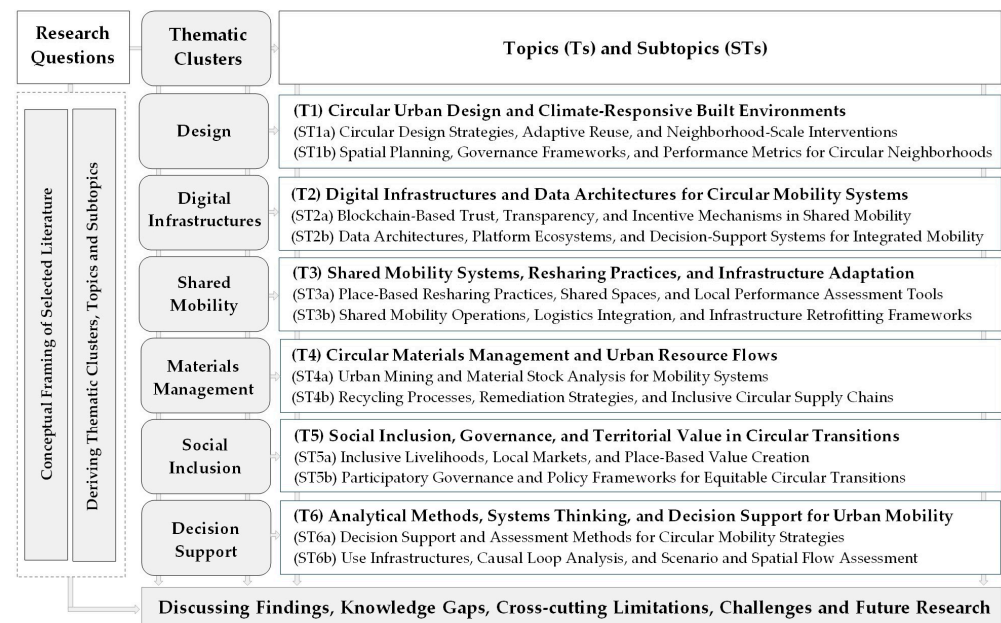


Figure 4. The structure of the literature review summarizing Ts and STs.

Table 1. Summary of T1 research organized by subtopic.

Authors (Country *)	Core Issue	Methodology	Results	Challenges
ST1a: Circular Design Strategies, Adaptive Reuse, and Neighborhood-Scale Interventions				
Seo (South Korea) [31]	Holistic framework for land use redevelopment.	Tegel Airport redevelopment, energy modeling, design synthesis.	Potential energy savings, resource efficiency, social cohesion.	Upfront costs, stakeholder coordination, long-term evaluation.
Brozovsky et al. (Norway) [32]	Climate-friendly neighborhoods comparative study.	Questionnaire survey, analysis of four case studies in China and Norway.	Use for photovoltaics and heat pumps; differences in building materials.	Integrating mobility and citizen engagement, regulatory gaps.
De Rosa et al. (Ireland) [33]	Energy transition in buildings and transport.	Expert synthesis and literature-based proposals.	Positive-energy buildings, renewables, storage, sustainable mobility.	Context specificity, financing, scalability, implementation.
Del Borghi et al. (Italy) [34]	Circular measures' impact on urban greenhouse gases (GHGs).	Global trade analysis project applied to four cities.	Reductions in Scope 1, 2, and 3 emissions.	Data gaps, cross-sector cooperation.
Tsaligopoulos et al. (Greece) [35]	Green walls and EVs for urban noise reduction.	Noise modeling and simulation in a medium-sized city.	Around 4 dB(A) reduction in simulated noise via circular actions.	Scaling citywide, contextual variability, policy integration.
Gravagnuolo et al. (Italy) [36]	Screening circular actions in historic port cities.	Comparative review and indicator screening across eight cities.	Identified strategic sectors (e.g., mobility) and gaps.	Lack of circular metrics and LCA applications.
Patnaik et al. (India) [37]	Adaptation of urban spaces and infrastructure.	Observational analysis, literature review.	Need targeted infrastructure, neighborhood-scale design interventions.	Risk of urbanization without local support.

Table 1. Cont.

Authors (Country *)	Core Issue	Methodology	Results	Challenges
ST1b: Spatial Planning, Governance Frameworks, and Performance Metrics for Circular Neighborhoods				
Anber and Hafiz (Egypt) [38]	Framework for tourism-dependent city.	Mixed (technical, evaluative, participatory).	70% emissions reduction through pilot projects.	Scalability, data integration, validation.
Soto et al. (UK) [39]	Integrating CE into socio-spatial planning.	Stakeholder interviews, and Glasgow case study.	Multi-scale urban circularity framework for mapping systems.	Cross-system integration and coordination.
Paoli and Pirlone (Italy) [40]	Actions for Genoa Circular Action Plan.	Review of municipal practices, framework design.	Toolkit for synergy across strategic sectors.	Translating plans into scalable actions.
Maillefert and Serra (France) [41]	Linking local economy and urban planning.	Conceptual analysis, territorialized framing of service-based models.	Framework integrating functionality economy into planning.	Translating theory into urban planning policies and practices.
Sharp et al. (Australia) [42]	Precinct-scale net-zero framing and transition management.	Interviews, secondary sources, framing analysis.	Identified priorities: electrification, place matters, going green, innovation.	Conflicting frames hide alternatives; resource scattering.
Moglia et al. (Australia) [43]	Derive mission-oriented pathways for green urban recovery.	Scoping review to define lessons, missions and integrated pathways.	Strategies for mobility, urban regeneration, resilient infrastructure.	Funding, policy alignment, measuring mission progress.
Leturiondo-Aranzamendi and De La Puerta-Rueda (Spain) [44]	Role of regional directives in territorial development.	Policy and participatory-process review.	Integrated strategies, binding determinations, and public engagement.	Enforcement and translating directives into local projects.
Duivenvoorden et al. (the Netherlands) [45]	Neglected public-space management in urban transitions.	Exploratory review and practitioner survey.	Integrated management unlocks urban potential.	Disaggregated funding, sectoral short-termism.
Crisostomi (Italy) [46]	Reframing planning toward climate-resilient soft cities.	Conceptual analysis using Rome Soft City proposal.	Integrated green networks and soft mobility planning.	Balancing policy vision with practical urban implementation.

* Country of the first author or host country of the project.

Table 2. Summary of T2 research organized by subtopic.

Authors (Country *)	Core Issue	Methodology	Results	Challenges
ST2a: Blockchain-Based Trust, Transparency, and Incentive Mechanisms in Shared Mobility				
Xing et al. (China) [47]	AI, blockchain, and IoT in circular supply chains.	800-professional cross-sectional survey with structured questionnaire.	Blockchain-tracked shared-vehicle life cycles enhance circularity.	Sectoral differences in digital capability; limited generalizability.
Sahoo et al. (India) [48]	Mapping blockchain research for urban mobility in smart cities.	Science-mapping and content analysis of Scopus articles.	Identified clusters, including blockchain-based urban mobility.	Scattered data; need for validation and governance research.
Pirrone et al. (Italy) [49]	Digital-enabled circular practices in WPM.	Five case studies, smart circular WPM framework, multi-level analysis.	Listed smart circular practices across life cycles stages.	Actor coordination, cross-system integration, pilot scalability.

Table 2. Cont.

Authors (Country *)	Core Issue	Methodology	Results	Challenges
Postorino and Sarnè (Italy) [50]	Car-sharing solutions to reduce congestion and pollution.	Reputation system and blockchain, tests on simulated and real data.	Improved trust and promising simulation and real-data results.	Scalability, privacy, regulation, interoperability, inclusion.
Hatzivasilis et al. (Greece) [51]	Hybrid trust-based system for resource sharing in VANETs.	SUMO simulation, tests on traffic of a small German city.	Energy-efficient communications in simulation and real deployments.	Lane-level positioning accuracy affects decision-making.
ST2b: Data Architectures, Platform Ecosystems, and Decision-Support Systems for Integrated Mobility				
Tunn et al. (The Netherlands) [10]	MaaS adoption and mobility inequalities.	Q-methodology and survey data.	People prefer convenience and low cost.	Platform design serving various users' needs.
Choudhuri et al. (India) [52]	Enterprise architecture (EA) for data-driven circular cities.	Design science research; artifact development for EA adaptation.	EA unifies business, analytics, IoT, cloud, blockchain for horizontal integration.	Complexity of cross-sector integration, need for institutional coordination.
Pamučar et al. (Serbia) [53]	Decision model for smart mobility circularity.	Scoring method with 10 experts ranking alternative mobility solutions.	Public transport and shared mobility ranked highly; model showed benchmarking potential.	Subjective expert weighting; limited stakeholder sample affecting transferability.
D'Amico et al. (Italy) [54]	Digital integration strengthens cities' metabolic circularity.	Systematic review combined with European case studies.	Digital initiatives boost monitoring urban metabolic flows.	Scaling integration across sectors; interoperability and aligned policy.
D'amico et al. (Italy) [55]	Digital technologies for urban metabolism efficiency.	Systematic review and European circular-city case studies.	Cataloged digital applications for mobility, energy, water and waste.	Consistent implementation, aligned policy, public engagement.
Viglioglia et al. (Italy) [56]	Information and Communication Technology (ICT) and district-scale solutions for CE.	Scoping review of nine case studies.	District scale effective for testing ICT solutions.	Scaling district pilots to citywide implementation.
McLean and Roggema (Australia) [57]	Enabling prosumer-focused utility and mobility via data.	Case study analysis of a Central Park precinct.	Demonstrated scalable prosumer services, circular flows, inclusion.	Required planning reform to scale prosumer infrastructure.

* Country of the first author or host country of the project.

Table 3. Summary of T3 research organized by subtopic.

Authors (Country *)	Core Issue	Methodology	Results	Challenges
ST3a: Place-Based Resharing Practices, Shared Spaces, and Local Performance Assessment Tools				
Di Marino et al. (Norway) [58]	Linking shared mobility, spaces and services.	Spatial observations (Løren, Oslo), regulatory review, dashboard development.	Identified spatial enablers for shared practices, developed dashboard to measure reshareability.	Consistent measurement of reshareability; generalizability across neighborhoods.
Uteng et al. (Norway) [59]	Barriers and potentials for resharing.	Workshops with residents and stakeholders; qualitative strategy analysis.	Revealed gap between stakeholder discussion and implementation.	Operational limits, coordination issues, pilots needed.

Table 3. *Cont.*

Authors (Country *)	Core Issue	Methodology	Results	Challenges
Scavarda et al. (Brazil) [60]	Sharing-economy impacts on urban social-ecological systems.	Systematic review (two-stage search), synthesis framework	Seven sustainable-sharing factors for interconnected value chains.	Integrating factors: equity, technology, measurement, governance.
ST3b: Shared Mobility Operations, Logistics Integration, and Infrastructure Retrofitting Frameworks				
Sarfraz et al. (Hungary) [61]	Sustainable shared-transport options under uncertainty.	Fuzzy logic, case study, sensitivity and comparative analysis.	Innovative multi-attribute group decision-making framework.	Computational complexity, data quality, stakeholder engagement.
Das et al. (India) [62]	Suitability of car-sharing models for Indian cities.	Scenario-based multiple-criteria framework with expert judgments; sensitivity analysis.	Carpooling preferred; accessibility and transport cost key indicators.	Context specificity, limited transferability, reliance on expert judgment.

* Country of the first author or host country of the project.

Table 4. Summary of T4 research organized by subtopic.

Authors (Country *)	Core Issue	Methodology	Results	Challenges
ST4a: Urban Mining and Material Stock Analysis for Mobility Systems				
Husmann et al. (Germany) [63]	Assessing EU vehicle stocks as secondary resource.	Material flow analysis (scenarios by 2050).	Shared mobility and battery chemistry limit secondary supply.	Aligning recycled-content targets with production-scrap recovery.
Wiedenhofer et al. (Austria) [64]	Map building and mobility material stocks.	High-resolution mapping (remote sensing and material-intensity).	10 m resolution material maps linking density and per capita stocks (279 tons/cap).	Transferability to other regions and integration into workflows.
Wiedenhofer et al. (Austria) [65]	Infrastructure stocks as drivers of material use and emissions.	Stock-flow model combining OpenStreetMap, archetypes, lifetimes.	Global mobility infrastructure holds 314 Gt of material stocks and 8 Gt/yr material flows.	Spatial inequality, lock-in, planning limits, reduction needed.
Frantz et al. (Germany) [66]	Quantifying mass of US built structures.	High-resolution mapping of 14 material categories.	Built mass exceeds biomass; higher per capita in rural areas.	Out-migration and legacy stocks hinder resource reuse.
Silvestri et al. (Italy) [67]	Assessing the circularity of rare earth elements (REEs) for mobility.	Review and thirty-year closed-loop modeling.	Recycling plus policy reduces REE demand.	High collection and recovery required.
ST4b: Recycling Processes, Remediation Strategies, and Inclusive Circular Supply Chains				
Amin et al. (Indonesia) [68]	Vulnerability of waste-pickers during circular transitions.	Surveys, interviews, participatory assessment, entropy-weighted regression.	Independent pickers most vulnerable; aggregators protected.	Informality, power imbalances, inadequate social protection.
Khare et al. (India) [69]	Toxic metals in compost prevent reuse.	Plant-based glutamic diacetic acid (GLDA) tested, optimized kinetics analyzed.	GLDA removed lead, cadmium, copper, and zinc with high efficiency.	Remobilization risks (technical); scale-up (industry).
Balaguera et al. (Colombia) [70]	Waste-derived stabilizers for rural road durability.	LCA of manufacture, transport, and stabilization stages.	Stabilizer manufacture drives most environmental impacts.	Trade-offs between waste use benefits and environmental impacts.

* Country of the first author or host country of the project.

Table 5. Summary of T5 research, organized by subtopic.

Authors (Country *)	Core Issue	Methodology	Results	Challenges
ST5a: Inclusive Livelihoods, Local Markets, and Place-Based Value Creation				
Carrasco-Bonet et al. (Spain) [71]	Networked ecosystems linking rural–urban mobile systems.	Spatial analysis combined with surveys; indicator development.	Connect rural–urban production and consumption via flexible systems.	Scaling ecosystemic planning across contexts; governance coordination.
Cottyn and Nijenhuis (The Netherlands) [72]	Mobility’s role in rural livelihood diversification strategies.	Household surveys; qualitative field observations.	Multi-locality and circular mobility support income, strengthen ties.	Inequitable access to mobility limits livelihood gains.
Marome et al. (Thailand) [73]	Transferring the R-CES approach to Thai cities.	Survey, stakeholder interviews, resource-flow and spatial analysis.	Feasible application, urban–rural dependencies were identified.	Governance and coordination gaps hinder implementation.
ST5b: Participatory Governance and Policy Frameworks for Equitable Circular Transitions				
Aina et al. (Saudi Arabia) [8]	Urbanization pressure shaping CE adoption.	668 articles reviewed via inductive content analysis.	Eight CE clusters; integrated transition framework.	Geographic gaps; limited empirical evidence.
Amasawa et al. (Japan) [74]	Strengthen consumption–production linkages for 2050 scenarios.	Participatory backcasting workshops; expert scenario design.	Identified consumption–production linkages and policy priorities (mobility included).	Political will, regulatory enforcement, end-of-life focus required.
Almulhim and Al-Saidi (Saudi Arabia) [75]	Assessing CE alignment in Saudi Arabia’s resource nexus.	Policy review, spatial-sectoral analysis, case synthesis.	Identified renewable, desalination, reuse initiatives, gaps integrating CE.	Need cohesive CE strategies, stronger policy integration.
Huss et al. (France) [76]	Identifying under-researched environment–health gaps in Europe.	Online survey of 318 researchers, expert evaluation.	Respondents reported 624 gaps; identified priority areas.	Required transdisciplinary funding, solution-focused research.
Patel S.J. and Patel C.R. (India) [77]	Low public bicycle sharing system ridership due to inadequate infrastructure.	Multi-criteria decision-making expert survey ranked implementation facilitators.	Top facilitators: infrastructure, technology, dedicated bike lanes.	Barriers: funding, public acceptance, integration, policy gaps.
Christis et al. (Belgium) [78]	City-level CE strategies’ climate-material footprint impacts.	City-level input–output analysis and footprint accounting.	CE strategies reduce carbon and material footprints.	Scope-3 emissions, rural reliance complicate local impacts.
Schröder et al. (Netherlands) [79]	Effects of unsustainable urban consumption on cities’ sustainability.	Transdisciplinary co-creation, participatory visioning, three case studies.	Case studies-framework for reducing footprints.	Scaling demands institutional change, stakeholder inclusion.
Dubresson and Jaglin (France) [80]	Rapid urbanization, governance erosion, rising fragmentation.	Literature synthesis and analysis.	Changing urban dynamics, rising informal economies, circular mobility.	Social inequality-driven fragmentation, weak policies.

* Country of the first author or host country of the project.

Table 6. Summary of T6 research, organized by subtopic.

Authors (Country *)	Core Issue	Methodology	Results	Challenges
ST6a: Decision Support and Assessment Methods for Circular Mobility Strategies				
Effendi et al. (Indonesia) [81]	Operationalizing sustainability in e-bike sharing.	Decision-support technique, surveys, interviews, expert validation.	IoT, AI, predictive maintenance improved reliability; higher user satisfaction.	Technical constraints, privacy concerns, limited adoption.
Wüstenhagen and Kirschstein (Germany) [82]	Substitution potential of light EVs.	LCA of municipal vehicle fleets; comparative LCA.	Light EVs halve environmental impacts.	Design for repairability and recycling infrastructure.
Pamucar et al. (Serbia) [83]	Prioritizing CE concepts for urban mobility.	Two-stage multi-criteria decision-making with case scenario.	Prioritized infrastructure for zero-emission vehicles to support SDG.	Resource, financial, and stakeholder constraints; management.
Logan (Canada) [84]	Questioning technology-led mobility solutions.	Critical historical analysis of suburban automobility.	Proposed repair-oriented, circular approaches for suburbs.	Digital exclusion, eroded trust, path dependence.
ST6b: Use Infrastructures, Causal Loop Analysis, and Scenario and Spatial Flow Assessment				
Scalisi (Italy) [85]	Reframing demand-side mitigation as design issues.	Design-led comparative analysis of nine cases.	Coordinated packages improve adoption, impact, and continuity.	Decentralized interventions, poor traceability, rebound.
Roncero-Tarazona et al. (Spain) [86]	Neighborhood-scale GHG mitigation potential.	Spatially explicit, scenario-based multisector assessment (Valencia case).	Reducing emissions (80%) through high-impact actions.	Reliance on grid decarbonization; uneven spatial impacts.
Suski et al. (Germany) [87]	Transforming household consumption via social practices.	Combining social practice theory and LCA, narrative approaches, case study.	Reducing impacts via practice change; bridging domains via narratives.	Measuring narrative influence; tool design for practice change.
Shams Esfandabadi and Ranjbari (Italy) [88]	Diffusion dynamics of urban car-sharing.	Systems thinking, causal loop diagram development.	Mapping stakeholder interactions via causal loop diagram.	Data availability, stakeholder coordination, policy alignment.
Fishman et al. (Israel) [89]	Scenario development for service provisioning futures.	Detailed scenario narratives across 20 regions to 2060.	Region- and period-specific parameters for transport services.	Integrating material cycles into global models.
Takayama et al. (Japan) [90]	Spatial equilibria and city system emergence.	General equilibrium model with commuting and transport.	Dependence of multiple stable urban configurations dependent on costs.	Translating theoretical equilibria into policy guidance.
Dąbrowski et al. (Netherlands) [91]	Knowledge transfer for CE innovation.	Networked living labs, interviews, surveys, participant observation.	Enabling context-sensitive solutions via co-creation in living labs.	Contextual mismatch and transfer barriers.

* Country of the first author or host country of the project.

3.1. Circular Urban Design and Climate-Responsive Built Environments

Sixteen contributions on Circular Urban Design and Climate-Responsive Built Environments (T1) in the design cluster, comprising empirical case studies, modeling, conceptual frameworks, and policy analyses, collectively provided a multifaceted foundation for integrating circularity into urban design to enhance value creation. Table 1 shows the research on T1 organized by STs: (ST1a) Circular Design Strategies, Adaptive Reuse, and Neighborhood-Scale Interventions [31–37], and (ST1b) Spatial Planning, Governance Frameworks, and Performance Metrics for Circular Neighborhoods [38–46].

Aligned with ST1a, Seo [31] proposed a holistic framework to convert brownfields into circular, resilient communities through adaptive reuse, phased implementation, integrated energy systems, and mobility innovations. The Tegel Airport case study linked theory to practice, demonstrating environmental, social, and economic co-benefits despite upfront costs and coordination challenges. Meanwhile, Brozovsky et al. [32] compared four case studies in China and Norway, identifying climate-friendly neighborhood types (e.g., positive-energy districts, zero- and plus-energy neighborhoods), shared technical solutions (e.g., photovoltaics, heat pumps), material divergences (i.e., concrete used in China, timber used in Norway), regulatory gaps, and weak integration of mobility and citizen engagement, with attendant policy-planning implications. Complementing this, De Rosa et al. [33] reviewed building and transport energy-transition technologies, such as positive-energy buildings, retrofits, distributed renewables, energy storage, electrification, modal shift and shared mobility; they highlighted enabling mechanisms like smart grids, financing, and governance, but noted a lack of empirical life cycle assessments (LCA) and comparative cost analyses. Del Borghi et al. [34] quantified the emission-reduction potential of circular interventions in energy, mobility and the built environment for four cities (Bogotá, Genoa, Milan, and Glasgow) using a Global Trade Analysis Project (GTAP) consumption-based modeling approach. They found substantial reductions in Scopes 1–2 and potential Scope 3 supply-chain reductions if measures were paired with electricity decarbonization. In mobility, modal shift and electrification substantially reduced Scope 1 (with largest effects in Milan and Glasgow), but electrification raised Scope 2 unless electricity was decarbonized; Scope 3 reductions were small at the city level but larger within the motor vehicle supply chain. Limited data, weak cross-sector collaboration, and a scarcity of quantitative studies on urban circular measures highlighted the need to account for consumption-based emissions and clean electricity to effectively guide neighborhood-level climate strategies. Further, Tsaligopoulos et al. [35] showed that urban circular measures for cities, such as green walls and electric vehicles (EVs), can reduce noise and deliver sustainability benefits. Their Mediterranean modeling found nearly 4 decibel reductions, supporting nature-based solutions and electric mobility. However, scaling up, long-term maintenance, and ensuring local adaptability remain challenges needing more empirical testing [35].

Alongside these findings, Gravagnuolo et al. [36] applied circularity thinking to entire cities and historic areas, checking how well cities reuse their existing buildings and proposing ways to measure progress before and after interventions in historic port cities. Meanwhile, Patnaik et al. [37] explored a different side of circularity by looking at seasonal workers who move temporarily to share skills but may end up staying permanently if local infrastructure fails to support their return [36,37]. ST1a literature converged across methods (conceptual frameworks [31,33], comparative typologies [32], quantitative emission modeling [34], and monitoring tools [36]), constituting a multi-method foundation that linked design interventions to environmental outcomes and social co-benefits [35]. Other studies related adaptive reuse and design to measurable material stocks and GHG impacts [31,34], and proposed decision tools (e.g., dashboards, indicators) applicable to urban mobility strategies (such as shared mobility siting and infrastructure repurposing). Nonetheless, empirical evidence connecting neighborhood-scale design to sustained mobility behavior change remained limited; mobility was often treated as an adjunct rather than a primary design outcome [31,32]. Del Borghi et al. [34] showed emissions-reduction potential but were constrained by small city samples and GTAP modeling assumptions, limiting transferability across contexts. Research gaps included longitudinal life cycle and cost-comparison data, scalability testing, innovative financing for adaptive reuse that prioritized mobility decarbonization, and comprehensive metrics capturing material circularity

and modal shifts over time and contexts. Priority actions should include strengthening education, behavior change, and stakeholder co-creation through innovative, gamified engagement [15], conducting longitudinal evaluations of adaptive-reuse projects [31], integrating mobility planning into positive-energy neighborhood design [32,33], performing LCA and cost-benefit analyses [32,34], and validating expanded co-benefit metrics over time and across spatial scales [35]. Patnaik et al. [37] addressed another perspective of circularity and underscored the socio-spatial stakes of mobility dynamics, noting that seasonal, skill-transferring migration can become permanent without adequate local infrastructure.

Unlike ST1a, research on ST1b emphasized spatial planning, governance frameworks, and metrics for circular neighborhoods, consolidating advances in policy instruments, stakeholder processes, and measurement systems to enable circular mobility transitions [38–45]. Anber and Hafiz [38] proposed a practical roadmap to transition Sharm El-Sheikh into a carbon-neutral, green, smart, and safe tourism city, employing Geographic Information System (GIS) mapping, Internet of Things (IoT) sensing, Environmental, Social, and Governance (ESG) assessment, United Nations Environment Programme (UNEP) carbon accounting, and participatory stakeholder input. Pilot interventions, notably smart waste management, reduced persistent organic pollutant emissions by approximately 70%, exceeding national targets, while integrated renewable energy and smart mobility scenarios projected total carbon reductions of 30–45% by 2035. The study developed a transferable policy framework for sustainable, climate-resilient tourism cities. In turn, Soto et al. [39] proposed a socio-spatial urban circularity framework and stakeholder-mapping approach for Glasgow, visualizing assets and initiatives across building, social-productive, energy-mobility, and ecological systems to support integrated planning, cross-scale stakeholder engagement, and alignment of mobility with other urban systems. Further, Paoli and Pirlone [40] developed an intersectoral methodological framework for Urban Circular Action Plans and applied it to Genoa to coordinate cross-sector circular policies and actions across mobility, energy, waste, and the built environment. Complementing these contributions, Maillefert and Serra [41] theorized territorialized service and functionality-economy models that reframed territorial value and governance for mobility at territorial scales. In turn, Sharp et al. [42], using interviews and documents from Melbourne’s Monash Technology Precinct, showed how four dominant frames (Electrify Everything, Place Matters, Going Green, and Innovation Hotspot) produced different problem definitions, trade-offs, and political barriers that shaped mobility and circular strategies. Together these studies advanced cross-scale, cross-sector understanding but pointed to a clear gap: practical governance tools were needed to turn territorial models into actionable Urban Circular Action Plans and to reconcile competing frames across scales. Moglia et al. [43], via a scoping review, articulated three mission-oriented pathways for green recovery: accelerating mobility transitions, achieving regenerative development, and creating resilient infrastructure, and defined six integrated pathways explicitly linking urban mobility with regenerative development. Further research [44] illustrated how binding territorial directives, participatory processes, and planning principles (CE, health, mobility) can institutionalize missions into sustainable territorial policy. In doing so, Duivenvoorden et al. [45], from a literature review and a practitioner survey, argued that strategic public-space management was a neglected but decisive lever for integrated urban transitions, identifying budgetary blind spots and calling for integrated, long-term governance, research, and policy reform. Crisostomi [46] reframed urban planning for climate change through the Soft City concept, using Rome, Italy, as an experimental case to advocate context-sensitive, low-emission, circular, and land-conscious interventions that integrated environmental protection, spatial morphology, and socio-economic dynamics into practical urban policy. Thus, ST1b studies emphasized multi-scalar planning [39], stakeholder co-creation [41], governance instruments [38,42],

and engagement tools [40,44] to enable mobility transitions. Visualization and mapping supported targeted engagement and monitoring [39], while comparative case analyses illustrated how governance conditions shaped prioritization between circular and mobility strategies [38,42,44]. Theoretical work on service-based models [41] and attention to public-space asset management reframed long-term operational budgets as strategic levers [41,45]. However, empirical evidence on policy effectiveness and longitudinal behavioral or material circularity outcomes remained limited: stakeholder mapping and performance metrics were frequently incomplete and rarely connected to quantifiable impacts at the service level, highlighting the need for standardized evaluation frameworks for impact assessment and operational governance tools [40–42,45]. Many governance studies also assumed institutional capacities that may be lacking in less resourced contexts [42].

Research on ST1a produced place-based design tools and material-stock data, while studies on ST1b advanced governance and engagement frameworks; however, operational links translating these insights into planning rules or mobility-service design remained limited. Studies emphasized standardized multi-metric monitoring systems integrating material circularity, Scope 1–3 GHG accounting, and mobility behavior [34,36], and called for impact-evaluative, longitudinal assessments of stakeholder-driven interventions [39,40]. Comparative longitudinal evaluations benchmarked by such metrics were lacking. Mobility was frequently treated as one sector among many [36,40,42], underscoring need for targeted empirical research on financing models and public-space management to mainstream circularity [44]. Some studies [33,35] highlighted e-mobility, noise reducing benefits, and digital and technological solutions as practical levers that could be more explicitly linked to circular neighborhood design. Frame pluralism [42] and territorial governance examples [44] further underscored the requirement for cross-scale institutional mechanisms and dedicated financing. Although policy mixes, public–private partnerships and regulation were recommended [41], piloted, gamified participation needed pairing with concrete policy levers [16]. While operational links to financing and public-space management remained insufficiently scaled, selected case studies and pilots demonstrated tangible implementation examples [31,38]. The literature provided conceptual, technical, and governance building blocks for circular neighborhood design but lacked operational linkage: design and material evidence from ST1a had to be translated via ST1b’s governance, financing, and metrics to deliver sustained mobility outcomes (e.g., shared fleets, reduced car dependence, infrastructure reuse). Mobility should be a core design goal in positive-energy neighborhoods [31–33]. In addition, core operational instruments involved procurement frameworks, public-space asset oversight, and finance to mobilize on-site materials and service models [41,42,45], while validated co-benefit metrics (noise, health, jobs) and participatory, gamified, or mission-based tools were priority frontiers for driving behavioral adoption [16,35,43].

3.2. Digital Infrastructures and Data Architectures for Circular Mobility Systems

Articles on Digital Infrastructures and Data Architectures for Circular Mobility Systems (T2) covered two connected strands of digitalization for circular mobility [10,47–57]: designing integrated urban platforms, using sensors and sharing services to manage city resources (e.g., [48,49,51]), and developing analytical methods to compare mobility options (e.g., [52,53,55,56]). Table 2 organizes the research by STs: (ST2a) Blockchain-Based Trust, Transparency, and Incentive Mechanisms in Shared Mobility [47–51], and (ST2b) Data Architectures, Platform Ecosystems, and Decision-Support Systems for Integrated Mobility [10,52–57]. Grouping studies into ST2a and ST2b revealed how two technical approaches depend on each other: trust and incentives without scalable data and platform integration are constrained, while rich data infrastructures without robust governance and

trust mechanisms can create dependence on specific platforms, limiting choices, exclusion, and producing misaligned incentives; e.g., [47,48].

ST2a combined empirical and conceptual approaches [47–51]. It included rigorous empirical work [47], systematic mapping [48], case-based ecosystem analysis [49] and applied system designs [50,51], which together address technology, governance, and operational dimensions. Within ST2a, Xing et al. [47] surveyed 800 respondents (400 per sector) across urban mobility services and consumer-electronics rental (and refurbishment), assessing how artificial intelligence (AI), blockchain, and IoT affected supply-chain transparency and circular performance, with reverse logistics efficiency (RLE) as a moderator. Findings differed by sector: blockchain and RLE were especially important for mobility services, while IoT had stronger direct effects for electronics [47]. Sahoo et al. [48] mapped the research landscape for blockchain in smart cities, identifying five knowledge clusters (including blockchain for urban mobility and for governance) and proposing future research directions; however, their review offered limited interpretive depth on technological constraints and socio-political trade-offs. Pirrone et al. [49] found that digital tools can support circular practices in waterborne passenger mobility (WPM), arguing that multidisciplinary, ecosystem-based approaches and system integration reduced congestion, emissions, and infrastructure needs; their study of five northern European cases using the smart circular WPM framework also pointed out gaps where more research is needed. Postorino and Sanrè [50] designed a blockchain-based reputation system for peer-to-peer car-sharing to reduce urban congestion and improve daily life. The system used public trust scores and automated contracts to build confidence between users, set fair prices, and remove intermediaries. Testing with real and simulated data showed greater trust and fewer conflicts. However, the study did not fully explore whether the system could scale efficiently or safeguard personal data, and it cautioned that unchangeable reputation records might trap users with past unfair ratings. The authors advised running pilot projects first to check scalability, privacy, rules, and fairness before expanding further [50]. Within this framework, Hatzivasilis et al. [51] proposed a trust-based architecture for Vehicular Ad hoc NETWORKS (VANETs), using cloud and 5G to enable secure, scalable resource sharing in transport contexts.

However, the hybrid architecture reintroduced a degree of centralization that blockchain proponents often sought to avoid, and interoperability with blockchain-based identity and reputation systems was not fully explored. Together, the ST2a studies highlighted that blockchain's value goes beyond immutability to enable shared, auditable provenance and incentive mechanisms across multi-actor mobility ecosystems. Empirical work [47] found blockchain integration mattered most where asset sharing and multi-party data exchange were intrinsic (e.g., shared fleets and peer-to-peer car-sharing [50]). Persistent tensions remained over privacy versus transparency, blockchain scalability and latency for real-time vehicle interactions, and the governance risk that unchangeable records could reinforce inequities or block correction. Some authors advocated hybrid, layered trust architectures [50,51]. Methodologies ranged from large-sample statistical analysis to design prototypes and literature mapping, indicating a field moving toward more generalizable, context-sensitive evidence.

Aligned with ST2b, Tunn et al. [10] applied Q-methodology and surveys to identify seven traveler segments defined by MaaS attributes (cost, time, environment, convenience, privacy). They found that convenience and affordability typically outweighed sustainability and privacy, offering actionable behavioral insights for platform design while emphasizing context over demographic predictors; however, the Dutch sample limited generalizability and called for behavioral validation and deployment testing. Subsequent research advanced enterprise and urban architecture approaches [52,57]. In this context, Choudhuri et al. [52]

proposed an enterprise-architecture adaptation for Indian cities to achieve horizontal integration of urban services (mobility, safety, utilities) using cloud, IoT, and AI. Further, McLean and Roggema [57] documented Sydney's Central Park precinct as an exemplar of prosumer infrastructure. Both studies [52,57] provided practical, policy-oriented frameworks addressing governance, standards, and cross-sector integration and emphasized local adaptation. However, they risked technocratic bias and required empirical validation at scale, with careful attention to data governance, equity, and potential vendor lock-in. In other words, policymakers should pilot these frameworks with inclusive stakeholder engagement to evaluate scalability and distributional impacts.

Following that research, Pamučar et al. [53] used an expert-based scoring method and concluded that public transit and shared mobility were the best smart mobility options, but their small expert panel (10 people) limited how widely the result can be applied. D'Amico et al. [54] reviewed European circular-city projects and found that digital technologies in road infrastructure, including sensors, platforms and smart grids, can improve traffic management, boost resource efficiency, and lower design and maintenance costs. A complementary study [55] translated urban metabolic circularity into practical resource-efficiency management, describing municipal practices from six case studies and tools such as real-time meters, tracking systems, and sharing platforms. Both [54,55] offer useful, case-based insights but rely on qualitative descriptions, limiting their ability to establish causal effects [54,55]. Further, Viglioglia et al. [56] conducted a scoping review of nine case studies, showing that ICT-enabled data management and district-scale pilots can advance urban CE through physical and virtual infrastructures and user engagement; however, the limited case set called for broader, comparative evidence to support citywide scaling and policy adoption. Overall, ST2b literature emphasized that robust circular mobility depended on integrated, interoperable platforms and decision systems that translated heterogeneous sensor, usage, and economic data into actionable governance. Strengths included cross-scale integration framing and attention to socio-technical design choices—such as segmentation, enterprise architecture, and stakeholder engagement—that shape outcomes. Conversely, recurring weaknesses included scant empirical evidence that systems worked across different vendors and regions, not enough focus on fairness when user-producers or companies dominated, and a lack of long-term studies showing lasting circular benefits instead of temporary rebound effects.

The literature on T2 concluded that technology, governance, and data and platform design should co-evolve. Technical fixes alone (including blockchain) failed without socio-institutional design, and governance reforms required interoperable data standards to scale. Hybrid, layered architectures could mitigate blockchain limits for real-time needs. Key gaps remained (such as limited causal evidence and experiments, misaligned incentives, poor cross-vendor and jurisdiction interoperability, few large real-world deployments, and uneven attention to distributive justice), requiring interdisciplinary, long-term applied research combining technical design, institutional and regulatory analysis, behavioral experiments, and large-scale field validation.

3.3. Shared Mobility Systems, Resharing Practices, and Infrastructure Adaptation

Five articles in the shared mobility cluster focused on T3 (Shared Mobility Systems, Resharing Practices, and Infrastructure Adaptation) and were grouped into STs: (ST3a) Place-Based Resharing Practices, Shared Spaces, and Local Performance Assessment Tools [58–60], and (ST3b) Shared Mobility Operations, Logistics Integration, and Infrastructure Retrofitting Frameworks [61,62]. Table 3 summarizes T3 research organized by these STs.

The reviewed studies provided complementary contributions and combined place-based conceptualization and measurement with decision frameworks. Within ST3a, Di Marino et al. [58] advanced a neighborhood-scale resharing framework linking shared mobility, shared spaces, and service provision to spatial conditions and land use configurations. Complementarily, Scavarda et al. [60] identified seven sustainable-sharing factors—concerning landscape, mobility, knowledge, production and consumption, sustainable practices, digitalization, and geography—that underpinned a multi-scalar management framework connecting social and ecological approaches. Meanwhile, Uteng et al. [59] operationalized resharing concepts using participatory methods (e.g., resident and institutional stakeholder workshops) to link spatial observation and community perspectives with strategies and practical tools to advance resharing in the Oslo region.

Strengths across ST3a included mixed-method empirical grounding, explicit spatial linkage to sharing potential, and production of actionable planner tools (e.g., dashboards and embedding strategies) [58,59], consistent with the emphasis on digital insertion and knowledge sharing in [60]. Nonetheless, the evidence exhibited limitations that constrained generalizability and policy translation:

- studies were highly context-specific to Løren and the Oslo institutional environment [58,59], limiting transferability across divergent urban morphologies, parking and regulatory regimes, and social and cultural conditions;
- methodological reporting lacked key details (e.g., workshop sampling frames and recruitment procedures, sample sizes, inclusion criteria for marginalized or mobility-dependent users, indicator selection and weighting processes, and primary data sources) [59], undermining reproducibility and interpretive confidence;
- the dashboard and reshareability metrics were promising but lacked documented validation protocols, benchmarking against alternative datasets, standardized indicator definitions, and sensitivity testing to assess robustness to data variability and alternative assumptions [58];
- empirical pilot evidence demonstrating how proposed strategies overcame institutional, operational, and governance barriers (e.g., maintenance responsibilities, municipal–operator coordination), was limited [58,59];
- participatory engagement reporting did not clearly document scale or inclusivity, and therefore likely under-represented vulnerable groups, risking biased priorities and inequitable outcomes [59].

To strengthen ST3a, recommended evidence-focused actions were as follows:

- implementing cross-context pilot trials in multiple neighborhood typologies with pre- and post-evaluation metrics (e.g., operational performance, equity indicators, maintenance costs) [58];
- publishing standardized reshareability indicator sets with clear construction rules, sensitivity analyses, and benchmarking datasets to enable comparability and reproducibility [58,60];
- documenting participatory methods and sampling in full, and adopting targeted inclusion strategies for marginalized and high-dependency users [59];
- linking dashboard outputs to explicit policy and procurement instruments to demonstrate institutional feasibility [58,59].

Under ST3b, Sarfraz et al. [61] introduced advanced parametric aggregation operators and a multi-attribute group decision-making framework that improved model flexibility for uncertain operational choices. However, the approach was highly technical and parameter-heavy, which may have hindered understanding and uptake by planning practitioners. User-friendly interfaces and additional sensitivity testing across real-world contexts

were therefore needed to support practitioner adoption. In turn, Das et al. [62] applied a scenario-based multiple-criteria decision-making (MCDM) approach in Mumbai to identify policy-relevant outcomes (e.g., carpooling preference; importance of accessibility and transport cost), but heavy reliance on expert judgment and scenario assumptions limited transferability and may have under-represented real behavioral and policy dynamics [62]. Both ST3b studies would benefit from clearly linking model outputs to retrofit design, contracting approaches and structures, and implementation plans, and from empirical validation through pilot projects, behavioral data collection, and cross-city comparisons [61,62]. To translate these insights into policy and practice, future research should prioritize cross-context validation, develop practitioner-oriented, transparent versions of complex models, conduct pilot implementations that connect recommendations to governance and retrofit pathways, and systematically integrate behavioral and equity evidence to ensure feasible, inclusive, durable, and scalable resharing strategies.

3.4. Circular Materials Management and Urban Resource Flows

The literature on Circular Materials Management and Urban Resource Flows (T4) in the materials management cluster was divided into two complementary threads relevant to smart city transportation: (ST4a) Urban Mining and Material Stock Analysis for Mobility Systems [63–67], and (ST4b) Recycling Processes, Remediation Strategies, and Inclusive Circular Supply Chains [68–70]. These eight studies, summarized in Table 4, provided spatially resolved evidence, methods, and cautionary findings that directly informed smart city decisions on maintenance, electrification, shared mobility, and network resilience.

ST4a research delivered foundational spatial inventories and prospective material flow analyses enabling planners to treat cities as both consumers and secondary suppliers of mobility materials [63–66]. Researchers combined material flow analysis (MFA) and stock-flow consistency with high-resolution Earth observation and crowdsourced geodata (e.g., OpenStreetMap) to produce settlement-scale, national, and global maps of building and mobility stocks [64–66]. Husmann et al. [63] used a forward-looking material flow analysis to assess the EU vehicle “urban mine”, explaining how cars at end of service life and manufacturing scrap could supply battery materials. They found that meeting the EU’s recycled-content targets was only realistic if manufacturing scrap was recycled, and that the share of materials recycled more than once was likely below 5%. Wiedenhofer et al. [64] produced high-resolution (10 m resolution) maps for Ireland and the UK, quantifying about 20 Gt (around 279 tons/cap) of building and mobility stocks and showing density-dependent patterns: building stocks per capita were similar across medium-high densities, while infrastructure stocks per capita declined with density and differed between countries for comparable building stocks. A related study [65] estimated 314 Gt of global road and rail infrastructure (around 41 tons/cap), revealing stark per capita gaps (23 tons/cap in low-income versus 130 tons/cap in high-income countries) and 8 Gt/yr of expansion and maintenance flows (corresponding to 0.36 Gt CO₂ eq/yr), about two-thirds of which stemmed from maintenance and replacement, signaling infrastructure lock-in and pronounced spatial inequality. In turn, Frantz et al. [66] found analogous heterogeneity in the conterminous US: high-resolution inventories across 14 material categories showed lower per capita stocks in dense urban cores and outsized per capita burdens in sparsely populated areas, worsened by out-migration and legacy infrastructure. Further, Silvestri et al. [67] modeled thirty-year closed-loop scenarios for REEs in vehicle batteries, showing that current recovery technologies combined with supportive policies could reduce REE demand from the mid-2020s, but that high collection and recovery rates were essential for economic and supply-risk benefits.

For smart city transportation, ST4a studies offered practical operational and policy insights: (1) high-resolution stock maps identified recovery hotspots for targeted deconstruction and urban-mining pilots; (2) stock-flow scenarios quantified potential secondary supplies for EV batteries, road repairs, and asset replacement under different reuse and recycling assumptions; (3) maintenance versus expansion diagnostics highlighted where limiting stock growth and prioritizing upkeep can reduce embodied emissions and avoid long-lived material lock-in [63–66]. However, ST4a also had important limitations: optimistic or inconsistent assumptions about future technologies, collection and recovery rates, battery chemistries, product lifetimes, and recycling efficiencies [63,67], frequent omission of toxicity and life cycle trade-offs [64,66], limited treatment of the informal sector [67], and uneven uncertainty reporting [63,65], all of which complicated the direct translation into procurement and operations planning. To improve policy readiness, future research should standardize assumptions and uncertainty reporting, incorporate life cycle and toxicity analyses, strengthen empirical evidence on collection and recovery, and validate mapping methods across diverse contexts.

In turn, ST4b complemented spatial quantification by examining downstream processes, remediation technologies, environmental life cycle trade-offs, and social impacts that determined whether urban mining could become an equitable, low-risk supply strategy for transport systems. Amin et al. [68] used the Livelihood Vulnerability Index (LVI) to show that independent and seasonal waste-pickers in Surakarta, Indonesia, were most at risk from circular transitions; to prevent regressive outcomes, they recommended formally recognizing these workers, establishing cooperatives, and providing social protection. Further, Khare et al. [69] developed and optimized GLDA, a biodegradable chelator that removed lead, cadmium, copper, and zinc from municipal compost at laboratory scale, but flagged remobilization risks and called for pilot-scale validation, monitoring, and life cycle and cost assessments before reuse in transport applications such as embankment or stabilization materials. Balaguera et al. [70] applied LCA to low traffic road stabilization with waste materials and found that stabilizer manufacture accounted for roughly 60% of impacts, notably abiotic depletion, global warming potential (GWP), and terrestrial ecotoxicity; in turn, the stabilization and application stage, particularly when using ash or brick dust, contributed sizable impacts in ecotoxicity-related categories, highlighting trade-offs between material recovery and environmental risk in transport infrastructure. However, ST4b studies varied in scale, assumptions, and transferability: Khare et al. [69] called for trials and comparative LCAs, while Balaguera et al. [70] showed that LCA outcomes depended on boundaries, functional units, and exposure models used to estimate ecotoxicity. For smart city transportation, ST4b findings were crucial: remediation and reuse options should be judged not just on resource value but also on toxicity, long-term performance, and social equity before being used in procurement or scaled up in public projects. Inclusive governance, including formal recognition, cooperatives, and social protection, was necessary to integrate informal workers without harming livelihoods [68]. The studies also cautioned that benefits from waste-derived stabilizers or recycled materials may be outweighed by manufacturing impacts or ecotoxicity, underscoring the need for LCA, toxicity testing, and assessment of local exposure pathways for transport applications [69,70].

Bridging ST4a and ST4b is essential for smart cities to design realistic, responsible circular mobility strategies. However, cross-cutting limitations included: reliance on optimistic collection, recovery, and recycling assumptions to meet policy targets [63], limited treatment of abrupt technological discontinuities such as battery-chemistry shifts and rapid shared-EV adoption [65], and treatment of social actors, especially informal sectors, as externalities rather than integral system components [66,68]. Few studies fully integrated spatial material flow analysis and high-resolution stock maps with LCA, ecotoxicology,

and long-term fate assessments, which left key trade-offs underquantified for transport applications [69,70]. Moreover, concrete pathways to translate high-resolution maps into recycling logistics, regulatory procurement, circular public-works contracts, and investment decisions remained underdeveloped [64,65].

Policy and practice implications for smart city transportation from T4 included:

- prioritizing production-scrap recycling and design-for-recycling to improve the viability of recycled-content mandates for EV batteries and infrastructure components [63];
- using high-resolution stock maps to target recovery hotspots, avoiding unnecessary new construction, and optimizing maintenance to reduce embodied GHGs and material lock-in [64,65];
- combining technical circular solutions with formal recognition, cooperatives, and social protection to safeguard informal workers and ensure equitable transitions [68];
- requiring LCA and toxicity screening for waste-derived materials before adoption in transport projects, while pursuing cleaner production of stabilizers and monitored remediation pathways [69,70].

The priority research agenda for smart cities was to develop integrated, spatially resolved socio-technical models that couple stock-flow inventories with governance, market behavior, logistics, informal-sector dynamics, and environmental fate to assess realistic circular pathways and distributional effects [63–66,68]. Empirical data on collection logistics, costs, regional recycling technologies, especially for batteries [63,67] and REEs outside Europe [67], together with longitudinal remediation outcomes [69], and policy simulation using spatial maps (e.g., recycled-content mandates, repair incentives) [64,65], will enable planners to translate urban-mine potential into actionable maintenance and equity-oriented transport policies [63–65,69]. Bridging high-resolution material intelligence [64,65] with LCA and toxicity analyses [66,70] and social-inclusion research [67,68] is essential for smart cities to achieve sustainable, circular mobility systems that advance social equity [63–70]. To realize this agenda, future work must address heterogeneity in spatial scale, methodological assumptions, and data quality across existing studies through standardized scenarios, sensitivity analyses, and local validation.

3.5. Social Inclusion, Governance, and Territorial Value in Circular Transitions

Eleven articles addressing T5 in the social inclusion cluster were linked to STs shown in Table 5: Inclusive Livelihoods, Local Markets, and Place-Based Value Creation (ST5a) [71–73], and to Participatory Governance and Policy Frameworks for Equitable Circular Transitions (ST5b) [8,74–80].

Aligned with ST5a, the research collectively reframed mobility not merely as movement through space, but as an active mechanism of socio-economic integration that shaped livelihoods and territorial resilience. The three studies concerning municipal markets in Girona [71], rural–urban linkages in Rwanda [72], and city-region resource flows in Udon Thani [73] operated across complementary contexts and scales and together offered convergent insights for smart city transportation advancing CE objectives while promoting inclusive, place-based value creation and territorial cohesion goals. In this context, Carrasco-Bonet et al. [71] conceptualized open municipal markets as networked ecosystems. Drawing on spatial analysis, surveys of 300 market actors, and four operational indicators, such as recurrence, variety, closeness, and rootedness, the study moved beyond static typologies to frame vendors as mobile connectors linking rural producers and urban consumers. Its strengths lay in the novel indicators and in treating mobility as a mechanism for territorial cohesion and food sovereignty. However, the study insufficiently addressed power asymmetries among market actors (notably between producers and intermediaries) and infrastructural constraints such as transport, storage, and cold chains.

Although the authors recommended multimodal, low-cost logistics and better connections between markets and transit for smart city planning, they did not articulate clear pathways for integrating these recommendations with existing mobility governance and investment frameworks [71]. Cottyn and Nijenhuis [72] found that households in northwest Rwanda used varied, short-term mobility strategies (temporary migration, circular travel, commuting) instead of straightforward rural-to-urban moves. Mobility therefore created opportunities for some but increased precarity for others. For smart city transportation, this means planners should (1) support circular and short-term travel with affordable, flexible intermodal links and schedules, and (2) apply equity lenses to avoid privileging better-resourced households. The study's local focus limited how widely its findings apply; comparative research would help identify more actionable policy levers. In this context, Marome et al. [73] extended the discussion to the city-region level, proposing the regional circulating and ecological sphere (R-CES) framework to harmonize resource flows and promote urban–rural self-sufficiency. Their study in Udon Thani identified material interdependencies in food, water and mobility, and found resident receptivity to cooperative approaches. The framework offered a template to align transport planning with circularity, prioritizing low-carbon flows, localized supply chains and cross-jurisdictional coordination. However, the research could have more critically assessed governance capacity, fiscal mechanisms for scaling the framework, and how smart transport technologies (e.g., data platforms, demand-responsive transit) would be governed to ensure inclusive benefits [73]. Together, these studies found that inclusive livelihoods and local value creation depended on flexible, equitable mobility systems integrated with local economies [71–73]. They recommended further research on linking market-oriented mobility with last-mile logistics, creating equitable multi-scalar mobility for circular and multi-local livelihoods, and developing governance mechanisms that connect transport infrastructure with regional resource flows and social-equity goals [71–73].

Studies aligned with ST5b argued that technical fixes alone could not produce systemic urban circularity [8,74–80]. Across contexts, studies emphasized that governance arrangements, stakeholder engagement, and inclusive policy design were essential to translating CE principles into operational transitions. Reviewed studies identified gaps in research and practice, useful procedural tools, and ongoing barriers that impeded equitable outcomes. Specifically, Aina et al. [8] mapped urban CE research and highlighted governance and citizen engagement as a key theme for creating circular cities. The review identified multisector collaboration, aligned policies, and digital innovation as enabling mechanisms. It showed CE actions were increasingly tied to global sustainability goals, especially SDGs 11–12, and that cities required integrated governance to balance economic, environmental, and social trade-offs. The authors proposed a framework linking governance with technological and sociocultural change but noted limitations: uneven geographic coverage and nascent empirical evidence on how participatory governance affected distributional outcomes [8]; they also recommended more empirical studies across regions. Amasawa et al. [74] tested a participatory backcasting and scenario-design workshop in the Klang Valley, engaging experts from academia, industry, and government to map key consumption–production linkages toward 2050. Their method revealed region-specific mobility, household, and housing patterns and highlighted political will and regulatory enforcement, especially for end-of-life resource management, as critical implementation drivers. The study showed that structured, local foresight can produce relevant policy pathways and stakeholder legitimacy, but its reliance on expert participants left marginalized and informal actors under-represented.

Sectoral and national contexts highlighted the importance of embedding CE initiatives within broader policy architectures. Almulhim and Al-Saidi [75] assessed the resource

nexus in Saudi Arabia and argued that CE interventions required firmer integration with national visions such as Saudi Vision 2030, alongside regional initiatives, to prevent fragmentation. They observed that water and energy sectors had begun adopting circular measures, but maintained that an explicit, participatory CE strategy was necessary to secure equitable access and align technical projects with social objectives. Their analysis suggested that top-down national programs risked neglecting local governance processes and distributive impacts unless complemented by inclusive policy mechanisms and local monitoring [75].

Research agendas and evaluative studies likewise highlighted gaps in participatory and transdisciplinary inquiry. Huss et al. [76] found that transport, mobility, waste, and the CE were under-researched in the European environment–health nexus and called for transdisciplinary, solutions-oriented research that links science with policy and community practice. They argued that governance innovation would require reconfigured research funding and institutional arrangements to enable participatory, cross-sectoral problem solving. Complementing this, S.J. Patel and C.R. Patel [77] examined facilitators for public bicycle sharing systems in Indian cities and found that infrastructure, government policy, and technological enablers predominated in determining ridership and system viability, implying combined investments in hardware, regulation, and community engagement [76,77]. Christis et al. [78] conducted an input–output analysis in Brussels and found that consumption domains (including transport) were hotspots where CE strategies could substantially reduce carbon and material footprints, implying that governance should coordinate consumption-focused policies with production-side interventions to ensure equitable social benefits [78]. In turn, Schröder et al. [79] proposed a transdisciplinary framework to tackle consumption and lifestyle drivers of urban sustainability, illustrated with three city case studies. Dubresson and Jaglin [80] warned that governance shifts in francophone sub-Saharan Africa could undermine grassroots benefits and exacerbate inequality unless circular transitions deliberately included redistribution measures and informal actors. The literature found that participatory governance was necessary but insufficient for equitable circular transitions; procedural tools (e.g., participatory back casting, co-creation, scenario workshops) showed promise but needed fuller inclusion of marginalized groups. Policy frameworks must embed CE within national strategies and key sectors (water, energy, mobility), while transdisciplinary research and funding reforms were required to support implementation. For smart city transportation, these findings implied that equitable circular transitions demanded governance designs combining four elements: inclusive participation [8,74]; cross-sectoral policy alignment and embedding within national strategies [8,75]; targeted infrastructure investment and technological enablers [77,78]; and mechanisms for accountability and redistribution to protect informal and marginalized actors [80]. Absent these, technical innovations risked reproducing existing inequalities [8,74–78,80].

The reviewed work advanced socio-territorial, participatory, and analytical perspectives by centering markets, mobility, and governance [8,71–73]. Cities should focus on affordable, mixed-mode last-mile delivery, better market access, and monitoring that tracks equity when shaping transport policy. ST5a and ST5b suggested that smart city transport planning must pair inclusive, place-based mobility measures with integrated governance and foresight to enable equitable, circular urban transitions. Future research should pursue comparative longitudinal evaluations [8,74,76], develop equity-sensitive dynamic models linking mobility to material and carbon footprints [78,79], test institutional protections for informal actors [75,80], and embed monitoring frameworks in pilots to translate participatory visions into scalable, policy-ready solutions [8,74].

3.6. Analytical Methods, Systems Thinking, and Decision Support for Urban Mobility

The articles in the decision support cluster concerned specifically T6 (Analytical Methods, Systems Thinking, and Decision Support for Urban Mobility) and were associated with (ST6a) Decision Support and Assessment Methods for Circular Mobility Strategies [81–84], and (ST6b) Use Infrastructures, Causal Loop Analysis, and Scenario and Spatial Flow Assessment [85–91]. These strands indicated integration opportunities and potential hybrid workflows for policymakers. Table 6 organizes the related research by ST.

Reviewing articles related to ST6a identified four complementary contributions to circular mobility strategies: user-centered design, LCA, multi-criteria prioritization, and critical policy reflection, emphasizing decision support and assessment methods [81–84]. Effendi et al. [81] provided a practitioner-ready decision-support template that translated user requirements into prioritized technical and service interventions for e-bike operators. The authors operationalized sustainability in e-bike sharing by combining Quality Function Deployment (QFD) with a Product–Service System (PSS), gathering user needs through surveys and interviews and validating a House of Quality (HoQ) with expert review. The study showed how technical measures (IoT-enabled charging, predictive maintenance) and service strategies (fleet balancing, privacy-aware apps) can improve reliability and adoption, offering a practical template for operators. Wüstenhagen and Kirschstein [82] offered a complementary supply-side perspective by performing an LCA of light EVs compared with conventional internal combustion engine and fully electric small vehicles. They provided LCA-based quantitative indicators that informed municipal substitution decisions and design-for-repair priorities; their analysis identified vehicle mass and reparability as key levers for reducing embodied and use-phase impacts, enabling CE design choices and quantification of municipal substitution potential. Pamucar et al. [83] strengthened planners' methodology by proposing a two-stage multi-criteria framework: first, weighted criteria were derived from interrelationship mapping; second, a fuzzy compromise ranking prioritized circular mobility interventions under resource constraints. Their case prioritized infrastructure for zero-emission vehicles over lower-cost data solutions, highlighting long-term strategic framing for planners. Logan [84] framed decision support normatively, advocating participatory, repair-focused governance criteria to complement technical assessment tools. The study addressed reparability, equity, and the unequal impacts of technology-driven mobility futures, arguing that technical measures must be integrated with participatory decision-making to enable structural change.

Together these works charted a balanced agenda: practical design and assessment tools (user-driven approaches, LCA, and MCDM) were essential but had to be embedded within equitable governance and reparative strategies to realize circular and just urban mobility.

Studies within ST6b offered a diverse set of contributions for understanding how urban systems could be steered toward decarbonization and circularity [85–91]. Collectively, the works combined design thinking, spatially explicit scenario modeling, social practice perspectives, and systems mapping to illuminate the levers and limits of demand-side and place-based interventions. Scalisi [85] reframed demand-side mitigation as a design problem of “use infrastructures” and introduced the design evidence link (DEL) for ex ante configuration and ex post verification. The study used an extraction protocol, advocated coordinated intervention packages, and identified recurring failure modes, including digital exclusion, trust erosion, rebound, and path dependence, noting that conclusions rested on a small case set and transferability required testing across diverse governance and data-quality contexts [85]. Roncero-Tarazona et al. [86] presented a spatially explicit, scenario-based neighborhood assessment for Valencia, Spain, and showed that coordinated high-impact actions could reduce emission by more than 80%, assuming 50% implementation of mitigation measures and grid decarbonization, while also revealing strong intra-city

heterogeneity and sensitivity to electricity-grid trajectories. Suski et al. [87] introduced a behavioral and cultural perspective by combining social practice theory with LCA and narrative methods. Their neighborhood case showed that interconnected shifts across consumption domains yielded notable environmental gains and that narratives of “enough” could catalyze practice change, though scaling and operationalizing such narratives within policy instruments remained challenging. In turn, Shams Esfandabadi and Ranjbari [88] used causal loop diagrams to map car-sharing adoption dynamics, clarifying feedback among population behavior, urban planning, manufacturing, and pollution. The qualitative systems mapping supported holistic policy diagnosis but would have benefited from quantification or calibration to identify robust leverage points [88]. Two further studies provided complementary macro-scale perspectives: Fishman et al. [89] developed detailed service-provision scenarios to 2060 suitable for integration with larger models, while Takayama et al. [90], using a general equilibrium model, showed that commuting and transport costs produced multiple spatial equilibria, underscoring nonlinearity and contingency. Dąbrowski et al. [91] examined knowledge transfer and co-creation through networked living laboratories, offering practical lessons on contextualizing innovations rather than assuming direct transferability. Overall, ST6b advanced the field by integrating design, spatial assessment, social practice, and systems thinking; the articles collectively argued that effective urban decarbonization required place-sensitive scenarios and governance that bridged behavioral meaning, technical infrastructure, and systemic feedback.

Future research priorities include: (i) empirical validation of traceability devices such as the DEL across diverse governance contexts; (ii) quantification and calibration of causal maps to locate high-leverage interventions; (iii) coupling neighborhood scenarios with realistic grid and supply constraints; and (iv) methods for scaling narrative-based practice change. Together, ST6a and ST6b underscored the need for integrated, equitable, and empirically grounded transition pathways.

3.7. *Toward a CE-Integrated Urban Mobility Framework for Smart City Transportation*

This paper presents an inductive, literature-grounded review, derived from the examined articles, that synthesizes how CE principles can be integrated into urban mobility for smart city transportation and shows that such integration can materially reduce environmental impacts, improve asset utilization, and advance social value, provided technological, spatial, governance, and social levers are coordinated.

Empirical and conceptual studies converged on three main insights. First, place-sensitive design and material intelligence created the technical possibility for circular mobility (e.g., adaptive reuse, urban mining, design-for-repair, positive-energy neighborhoods), providing concrete levers for embodied-carbon reduction and secondary material supply when matched with realistic recovery rates and life cycle safeguards [31–37,63–67,82]. Second, digital architectures, platform ecosystems, and trust mechanisms could enable sharing, traceability and prosumer integration, but they required layered, interoperable systems and governance to promote choice, fairness, and responsible incentives [10,47–57]. Third, governance, inclusive participation, and equity-centered policies were essential: without institutions that managed public space and protected people, including informal workers, technical improvements risked reinforcing inequalities and leading to long-term entrenchment [38–46,68–76,80]. These pillars, such as design and materials, digital and operational systems, and governance and social inclusion, needed to be intentionally coupled to realize sustained circular mobility outcomes [31–34,41–45,47–49]. The conceptual framework in Figure 5 puts these pillars into practice by matching weaknesses and challenges with opportunities and strategies across policy, technical, and participatory areas, and by identifying cross-cutting levers (integrated policy and design alignment; capacity

building and technical toolkits; multi-context pilot standards; integrated decision-making platforms; inclusive territorial mobility; systems decision hub) to integrate CE principles into urban mobility for smart city transitions. To clarify the internal logic of Figure 5, each dotted-outline topic box groups one thematic area and each central lever aligns the left and right boxes for that same area. The upper and lower solid boxes within each dotted-outline topic box correspond to the two STs for that T, as identified in Figure 4. Each thematic area follows a vertical structure: “Weaknesses and Challenges” (left) documents empirically grounded barriers from the reviewed literature for the associated Ts and STs in Figure 4; the central cross-cutting lever names the enabling mechanism that transforms these barriers into actionable pathways; and “Opportunities and Strategies” (right) lists evidence-based responses. In brief, under the lever “Integrated policy and design alignment,” weaknesses and challenges such as high upfront costs, coordination failures, and limited longitudinal evaluation of adaptive reuse (ST1a) are matched with opportunities and strategies that embed mobility as a core design goal, require LCA and life cycle cost–benefit analyses, and support longitudinal studies of adaptive reuse. In this sense, each lever acts as a translation device that converts diagnosed gaps into prioritized research and policy actions.

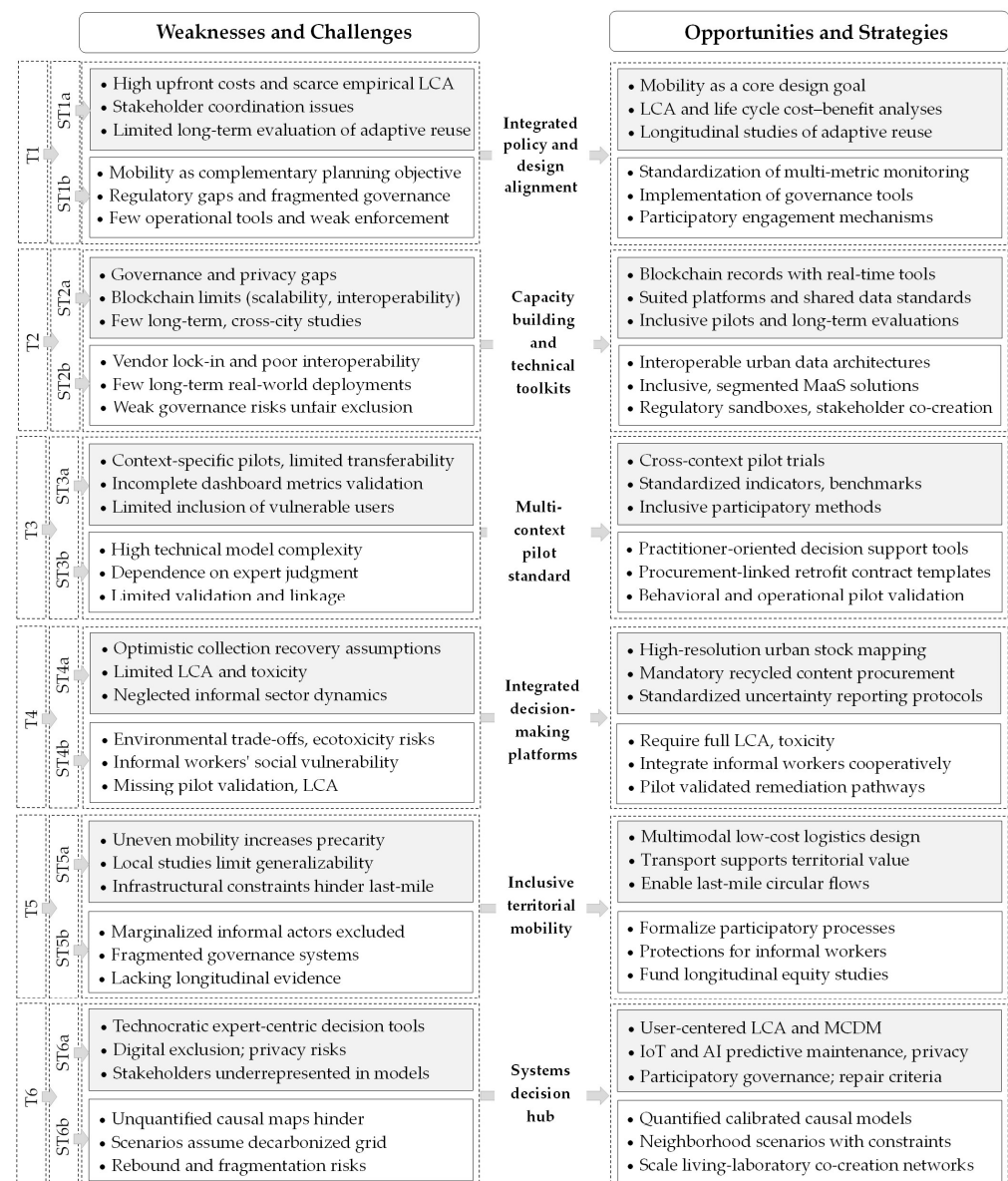


Figure 5. A systems map integrating CE principles into urban mobility for the Ts and STs.

The six levers work together as a practical sequence for circular mobility transitions: (1) integrated policy and design alignment creates the regulatory and strategic basis; (2) capacity building and technical toolkits supply methods, data, and interoperable infrastructures; (3) multi-context pilot standards test solutions across contexts to produce comparable evidence; (4) integrated decision-making platforms convert pilot and monitoring data into actionable planning intelligence; (5) inclusive territorial mobility ensures deployments advance equity and protect vulnerable groups; and (6) the systems decision hub closes the loop by enabling adaptive governance and learning through causal models, constrained neighborhood scenarios, and networks of living labs, allowing continuous improvement and scaling. Each lever establishes preconditions for the next, while explicitly supporting feedback loops (such as quantified causal models, constrained neighborhood scenarios, and living-lab networks) that allow earlier stages to be revised, validated, and scaled. Thus, the systems decision hub can generate feedback loops: quantified causal models (ST6b) inform policy alignment (ST1b) by revealing which governance levers drive modal shift; neighborhood scenarios (ST6b) revise pilot standards (ST3a) by identifying boundary conditions for success or failure; and living-laboratory networks (ST6b) feed inclusive mobility (ST5a) by formalizing participatory processes and longitudinal equity studies. These loops can ensure adaptive learning rather than a static checklist. However, the framework reflects the reviewed studies' geographic and methodological biases and should therefore be applied cautiously and adapted to local capacities and contexts.

The literature review yields these key findings:

- Many studies developed place-based tools (dashboards, MFA maps, LCAs, MCDM, scenarios, and pilots for district ICT, car-sharing, and urban-mining inventories), but few translated them into long-term public-works contracts or mobility-service designs, limiting scale and institutional uptake [34–36,50–56,64–66];
- Research often assumed optimistic collection and recovery rates, multi-loop recycling, and limited rebound effects; few combined high-resolution stock mapping with LCA and socio-economic inclusion analyses, constraining robust policy guidance [63–67,69,70];
- Digital trust and incentive systems (including blockchain designs) show promise for shared fleets and peer-to-peer services, but their effectiveness depends on regulatory fit, privacy regimes, layered real-time architectures, and inclusion strategies for marginalized users [47–57];
- Mobility is frequently treated as a sectoral add-on rather than a core design objective in neighborhood and circular projects; achieving modal shift and durable shared mobility requires explicit governance instruments (e.g., public-space management), participatory co-creation, and behavioral interventions [16,31–33,38–46];
- Circular transitions can displace existing livelihoods; to prevent worsening inequalities and retain local economic value, circular mobility strategies should provide targeted social protections and connect interventions to local supply chains and markets [68–73,75,80].

Priority actions for future research and practice include:

- running multi-year, multi-neighborhood pilots with registered protocols and standardized monitoring of material circularity, Scope 1–3 GHGs, mobility behavior, modal share, maintenance costs, and health/noise co-benefits [34,36,39–43,86];
- developing interoperable indicator sets linking stock-flow maps, LCA, toxicity assessments, cost–benefit frameworks, and social-equity metrics [64–67,69,70,82];
- designing hybrid trust architectures with open standards and privacy by design for inclusive MaaS and PaaS [47–57];

- embedding mobility targets in neighborhood plans and procurement processes [31–33,40–45];
- mandating social impact assessments and participatory governance in circular procurement [68–73,75,80];
- funding interdisciplinary research that combines systems modeling with pilot evaluation [61,62,85–91].

These recommendations depend on local institutional capacity and context and should be adapted, validated, and benchmarked across diverse settings before broad replication. Integrating CE into mobility can yield significant environmental and social benefits, but success requires scaling beyond isolated pilots into mainstreamed, governed, and equity-focused implementation. Scaling circular mobility requires coordinated experimentation, standardized metrics, and institutional commitments to inclusion and long-term monitoring; otherwise, the promise will remain fragmentary, context dependent, and unable to meet cities' converging climate and social challenges [31,37,47,57,63,70,81,91]. To realize CE-integrated urban mobility's environmental and social benefits, cities need coordinated design, interoperable digital platforms, and inclusive governance tested across diverse contexts. Key gaps remain in long-term, causal, and cross-scale evidence—especially integrated stock-flow analyses, LCAs, and standardized metrics to unlock financing. Cities, funders, and researchers should jointly run multi-neighborhood, pre-registered pilots with interoperable metrics and built-in equity safeguards.

The following section considers these findings to answer the paper's RQs and assess trade-offs and policy priorities.

4. Discussion

This section addresses RQs 1–3 by integrating findings across the thematic clusters (T1–T6 and their STs) described in Section 2, drawing on a curated corpus of 63 peer-reviewed articles identified in Scopus and WoS and summarized in Tables 1–6. Two search strings (“Circular Economy” and “Urban Mobility”) were used to collect papers; thematic synthesis assessed integration and identified gaps. Only studies explicitly linking circularity to urban mobility were included; those focused mainly on industrial implementation, regulatory frameworks, or normative topics were excluded. The review mapped the literature, highlighted pilot projects and evaluated implications for smart city transportation, which, despite numerous initiatives, remains a nascent domain for CE applications [7,10,92]. The research corpus was predominantly European (63.5%), likely reflecting stronger CE and urban mobility programs and the prioritization of SDG-related research across European countries. Following [8], the paper links design for urban mobility, governance, digital enablers, and measurement to map CE trajectories, showing that integrating design, platforms, and institutions is required to implement place-based CE actions. Figure 5 maps weaknesses and challenges to opportunities and strategies across policy, technical, and participatory domains through six cross-cutting levers (integrated policy alignment, capacity building, multi-context pilots, decision-making platforms, inclusive territorial mobility, and systems governance), offering a synthesis of relevant infrastructure, services, road space design, and assessment to answer RQs 1–3.

The literature showed that CE principles were operationalized when design interventions, such as material-stock management, design for reparability and adaptive reuse, were integrated with place-based planning, procurement rules, and governance instruments (T1, T4). Empirical and modeling studies indicated that adaptive reuse of built assets, procurement favoring recycled content, and design for reparability reduced embodied impacts and created urban-mining opportunities [31–33,64–66]. Place-based resharing practices, microhubs, and infrastructure retrofits aligned shared-mobility supply with local

land use and service provision (T3) [59–61]. Digital infrastructures and layered platform architectures, including provenance tools and reputation mechanisms, were necessary to verify material histories, coordinate shared fleets, and scale circular workflows, conditional on governance safeguards (T2) [48,49,51,54–56]. To enable circular cities, several studies argued that public-space asset management, mission-oriented finance, and binding territorial directives were required to translate technical and design interventions into implementable city plans (T1, T5) [38–40,74–76]. Meanwhile, only a few recent studies examined how to integrate AI into CE-oriented smart city models at scale, particularly regarding governance, scalability and validation of AI-enabled CE implementations [93].

The literature review recommended monitoring across multiple metrics that combined GHG accounting (Scope 1–3) [34,65], material stock and flow indicators for mobility infrastructure [64,66], modal share and travel behavior metrics [31,81,83], and inclusion indicators [65,68,88] (T1, T4, T6). Operational, SDG-relevant metrics tested in the literature mainly included modal share and accessibility measures (SDG 11), recycled content share and material recovery rates (SDG 12), and life cycle emissions per capita or per trip (SDG 13) [21]. Some studies stressed that indicators should be spatially explicit, longitudinal, and integrate material and behavioral dimensions to avoid double-counting and capture Scope 3 impacts [68,78]. However, many articles discussed indicators qualitatively or presented model and scenario outputs [88,90]; for many indicators the exact metric or value varied by study. By way of example, Table 7 lists selected topic-focused indicators relevant to the SDGs; these indicators reflect concepts and metrics synthesized from the reviewed research, with references for measurement details. The emphasis on SDGs 11, 12, 13 reflects the view that sustainability is a necessary condition for smart city projects to contribute to broader SDG targets [20,21,94–96]. There is a clear need for standardized metrics, minimum reporting standards, and uncertainty ranges to improve comparability across studies.

Table 7. Key SDG-relevant topic-focused indicators synthesized from the reviewed literature.

Indicator(s)	SGD(s)	Description	Unit	Source(s)
Modal share	11, 13	Share of trips by walking, cycling, public transport and shared modes	% of trips	[31]
Material stock per capita	11, 12	Mass of buildings and mobility infrastructure per person	tons/capita	[64,66]
Recycled-content; recovery rate (vehicles, components)	9, 12	Share of recycled content in products; share of end-of-life mass recovered	%	[63,67]
Embodied GHGs of mobility material flows	11, 13	Life cycle GHGs from material flows (such as expansion and maintenance)	t CO _{2e} /year; t CO _{2e} /capita; Gt CO _{2e} /year;	[34,65]
LCA emissions per vehicle	12, 13	Life cycle GHG emissions attributed to a vehicle type or transport service, normalized per passenger-km	kg CO _{2e} /passenger-km	[82,86]

Several authors recommended dashboards coupling high-resolution stock maps, MFA, LCA and mobility KPIs for ex ante and ex post monitoring (T1, T4, T6) [34,36,63–66,85–87]. This illustrated how CE principles can be operationalized in urban mobility planning, and how progress could be assessed using SDG-relevant indicators such as life cycle emissions, material reuse, modal share, addressing RQ1 (see Section 1). Research on urban mobility and the CE highlights opportunities to weave together economic, environmental, and social sustainability into smart city transportation [35,55,64,75]. Bringing these elements together can improve how efficiently resources are used, ensure fairer access, build stronger infrastructure, and create more inclusive decision-making processes. Ultimately, this bal-

anced approach helps cities thrive over the long run by weighing policy duties, community well-being, ecological stewardship, and practical execution [32,87,94,95].

Addressing how CE requirements can inform the design and assessment of alternative mobility systems to improve sustainability, efficiency, and resilience (RQ2, Section 2), the literature review focused on translating CE requirements into concrete design and policy measures (see Figure 5). The literature indicated that CE requirements were translated into vehicle and infrastructure specifications by embedding reparability, recoverability, and design-for-disassembly into technical standards (T1, T4) [31,34,63,67]. Shared mobility and resharing models were operationalized through place-based resharing strategies (e.g., microhubs, parking and curb-space retrofits, and localized service footprints) that aligned supply with land use (T3) [58–62]. Advanced algorithms and digital systems (e.g., predictive maintenance, provenance tracking, real-time fleet coordination) needed to be built into interoperable platforms with strong data rules to prevent vendor lock-in and the exclusion of users (T2) [10,47,48,51,53–55,92]. Assessment workflows used several complementary methods, such as LCA at component level, stock-flow MFA, multi-criteria decision analysis, and spatial scenario modeling, to evaluate trade-offs among cost, emissions, accessibility, and equity (T6). Practical tools, including QFD for PSS design, enterprise-architecture frameworks, and monitoring dashboards, were trialed to translate model results into procurement and operations and to validate findings through behavioral and operational pilots (T2, T6) [10,52,81,82]. The studies concluded that assessments must operate across scales and use multiple methods both to align short-term operational decisions with long-term circular goals for specific alternative mobility solutions (e.g., MaaS, PaaS, shared fleets, and EV infrastructure) and to account for rebound and distributional effects.

In response to RQ3 on how the implementation and performance of CE urban mobility initiatives at city and neighborhood scales influenced governance models, stakeholder engagement, and digitalization, the reviewed studies highlighted that place-based implementation, such as resharing pilots, microhubs, and adaptive reuse, reshaped local governance by aligning service provision with land use and community needs, creating new partnerships among public, private, and community actors and decentralizing some decision-making (T3, T5) [58–60,71–74]. These findings suggest that embedding CE principles in road and transportation design can support material efficiency, waste reduction, multimodal accessibility, public-space reclamation, and equitable low-carbon systems when governance arrangements are aligned [2,11,97]. Furthermore, performance-oriented digitalization (including predictive maintenance, provenance systems, and real-time coordination) translated operational requirements into contractual, institutional, and technical changes, as evidenced by blockchain-tracked vehicle life cycles that enhanced both circularity and digital integration [47], strengthened cities' metabolic circularity [54], and increased reliance on automated coordination, data governance, and interoperable platforms (see T2 in Table 2). Successful implementation depended on governance capacity, inclusive stakeholder processes, and financing. Participatory planning, binding territorial directives, and institutional coordination enabled the translation of circular ideas into action (T1, T5) [38–41,74]. Conversely, decentralized governance, weak financing, and exclusion of informal actors constrained scaling and risked regressive impacts (T4, T5) [63,68,71–73]. Digital trust mechanisms (including blockchain-based provenance and reputation systems) provided auditable life histories and incentive structures but raised trade-offs in privacy, scalability, and equity; studies recommended hybrid, layered trust architectures and democratic data stewardship to avoid entrenching inequities (T2) [47–51]. Authors emphasized that digital solutions and governance should co-evolve: technical systems require normative frameworks to convert digital traces into policy-relevant, equitable decisions [98].

The reviewed literature collectively treated CE in urban mobility as a socio-technical program: design measures, digital systems, metrics, and governance instruments were combined in case studies and modeling exercises and shown to reduce embodied impacts, enable circular supply flows, and support new service models when coherently aligned [31,36,47,57,63,66,81,86]. However, the evidence was limited by a scarcity of long-term impact studies and pilots across contexts, optimistic assumptions about recovery and recycling in some material flow analyses, incomplete coupling of MFA with LCA and toxicity testing, and a lack of empirical evidence connecting participatory governance to measurable mobility and material outcomes across T1–T6 [34,36,39,41,63,70]. As [99] suggests, framing the literature on CE and urban mobility revealed practical implications for smart city transportation: CE principles are most effectively operationalized when place-sensitive design and materials intelligence (T1, T4) are embedded in procurement and governance (T1, T5), supported by interoperable digital platforms (T2), evaluated using multi-metric assessment frameworks (T6), and trialed via shared mobility and resharing pilots (T3). Aligned with the study’s aim to help built environment stakeholders integrate CE principles and adopt a circular mindset in road design and construction, an underexplored area is the incorporation of circular strategies across the feasibility, design, construction, and maintenance of road systems, together with the integration and evaluation of advanced traffic control strategies in realistic scenarios [100–102].

5. Conclusions

This paper presents a literature-grounded review assessing how CE principles have been incorporated into urban mobility and the implications for smart city transportation. Scopus and WoS were searched for literature combining the terms “Urban Mobility” and “Circular Economy”, limited to peer-reviewed articles published from 2010 to mid-2026 to focus on comparable studies and to enhance methodological consistency, quality, and reproducibility within a homogeneous corpus. The review included only studies that explicitly linked circularity to urban mobility, excluding research focused primarily on industrial implementation, regulatory frameworks, or normative topics; thus, the articles’ contents guided the review. The review offers a broad multidisciplinary synthesis rather than deep technical or context-specific analysis. Thematic grouping involved subjective judgment, but the selection focused on studies addressing the joint search theme and yields useful insights for integrating CE principles into urban mobility for smart city transportation. The output is a conceptual framework that maps weaknesses and challenges to opportunities and strategies, and includes SDG-relevant indicators and policy recommendations.

By surveying recent developments, this review aims to inform the design of sustainable mobility and urban road planning strategies. In doing so, the paper makes two main contributions. Scientifically, it synthesizes a corpus of thematic, peer-reviewed studies into an integrative framework that links CE principles to urban mobility across six thematic clusters (Design, Digital Infrastructures, Shared Mobility, Materials Management, Social Inclusion, and Decision Support), identifies methodological gaps (e.g., missing LCA–MFA integration, limited longitudinal evidence), and proposes interoperable metrics and modeling priorities to advance rigorous evaluation across scales. Societally, the review translates its findings into structured, actionable guidance for planners, policymakers, and practitioners, highlighting public-space management and data governance as levers for equitable and sustainable urban mobility. By aligning weaknesses and challenges with opportunities and strategies across policy, technical, and participatory domains, the reviewed literature indicates that CE strategies—such as design for repairability and adaptive reuse, MaaS, PaaS and shared fleets, closed-loop maintenance, urban mining, and layered digital platforms—can materially reduce embodied impacts, increase asset utilization, and

improve resilience in smart city transportation when combined with coherent financing and governance. Digital systems (e.g., predictive maintenance) enabled optimization but introduced risks such as privacy concerns unless supported by interoperable architectures and clear data-governance rules. However, several persistent barriers slowed real-world adoption: uncoordinated decision-making, overly optimistic assumptions about recovery and recycling, limited integration of detailed stock-flow mapping with life cycle and toxicity assessment, a lack of long-term or pilots across contexts, and weak evidence connecting participatory processes to concrete mobility or material outcomes. Mobility was often treated as an adjunct rather than a primary design objective; therefore, embedding explicit mobility targets into neighborhood plans and procurement instruments is essential. Study findings were fragmented because pilots were highly specific to the context, assumptions about recovery and recycling varied, and LCA was rarely combined with MFA. Overall, CE approaches to urban mobility are feasible but not automatic: realized benefits depend on coordinated technical and policy design, common monitoring metrics, inclusive governance, and place-based testing to scale pilots into lasting policy and procurement. The authors acknowledge several limitations of the review approach: the search relied on peer-reviewed Scopus and WoS records, consequently excluding many practitioner reports, municipal evaluations, and pilot study data. Few long-term, multi-neighborhood studies with registered evaluation plans brought together material flow mapping, LCA, cost analysis, and measures of social impact, and reproducibility was constrained because underlying data and methods were often unpublished. However, the paper provides definitions and study-specific criteria intended to increase transparency while highlighting the need for future work to refine community-wide operational definitions.

To close these gaps, proposed recommendations include:

- testing integrated interventions at scale by running multi-year, multi-neighborhood, study pilots that combine high-resolution stock-flow mapping, LCA, logistics and cost analysis, and social impact monitoring to assess scalability, rebound effects, and equity;
- standardizing measurement and modeling by developing interoperable, spatially explicit indicator sets and multi-metric dashboards and apply data-driven causal and scenario models to prioritize interventions;
- mainstreaming circular procurement and asset management by adopting recycled-content requirements, performance-based contracts, and circularity criteria in public works and financing;
- enabling inclusive governance and evidence synthesis by piloting layered data governance frameworks with privacy by design, embedding informal-sector transition pathways with livelihood indicators, and incorporating grey literature to broaden both the coverage of municipal practices, technical reports, and pilot datasets relevant to local implementation, and the geographical origin of studies.

Implementing these steps can accelerate the translation of this study's conceptual insights into practical, scalable actions.

In conclusion, planners and policymakers should embed circularity into road infrastructure standards and procurement, test microhubs, shared-fleet resharing, and adaptive reuse within transit-oriented planning, roll out layered digital architectures with strong governance and interoperability, and invest in longitudinal evaluation and community engagement to safeguard social sustainability. Integrating AI, connected and autonomous vehicles, and road design into CE frameworks can deliver efficiency gains but should be governed to protect environmental, economic, and social outcomes aligned with sustainable development principles. Funding transdisciplinary, long-term research and embedding equity safeguards in all pilots will be essential to move from promising demonstrations to durable, scalable, and just circular mobility systems.

Author Contributions: Conceptualization, M.L.T., E.M. and A.G.; methodology, M.L.T., E.M. and A.G.; software, M.L.T., E.M. and A.G.; validation, M.L.T., E.M. and A.G.; formal analysis, M.L.T., E.M. and A.G.; investigation, M.L.T., E.M. and A.G.; resources, M.L.T., E.M. and A.G.; data curation, M.L.T., E.M. and A.G.; writing—original draft preparation, M.L.T., E.M. and A.G.; writing—review and editing, M.L.T., E.M. and A.G.; visualization, M.L.T., E.M. and A.G.; supervision, E.M. and A.G.; project administration, M.L.T., E.M. and A.G.; funding acquisition, M.L.T., E.M. and A.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data are available upon kind request to the corresponding author.

Acknowledgments: This publication is supported by the Rector’s pro-quality grant. Silesian University of Technology, grant number 12/040/RGJ25/0069, and BK-280/RT4/2026, 12/040/BK_26/0077.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

AI	Artificial Intelligence
CE	Circular Economy
ESG	Environmental, Social, and Governance
EV(EVs)	Electric Vehicle (Electric Vehicles)
GIS	Geographic Information System
GHGs	Greenhouse gases
GLDA	Glutamic Diacetic Acid
GTAP	Global Trade Analysis Project
GWP	Global Warming Potential
HoQ	House of Quality
ICT	Information and Communication Technology
IoT	Internet of Things
LCA	Life Cycle Assessment
LVI	Livelihood Vulnerability Index
MaaS	Mobility-as-a-Service
MCDM	Multiple-criteria decision-making
MFA	Material Flow Analysis
PaaS	Product-as-a-Service
P2P-CS	Peer-to-Peer Car-Sharing
PSS	Product–Service System
QFD	Quality Function Deployment
R-CES	Regional Circulating and Ecological Sphere
REEs	Rare Earth Elements
RLE	Reverse Logistics Efficiency
RQ (RQs)	Research Question (Research Questions)
SDG (SDGs)	Sustainable Developments Goal (Sustainable Developments Goals)
ST (STs)	Subtopic (Subtopics)
T (Ts)	Topic (Topics)
UNEP	United Nations Environment Programme
VANETs	Vehicular Ad hoc NETworks
WoS	Web of Science
WPM	Waterborne Passenger Mobility

References

1. Kapucu, N.; Ge, Y.; Rott, E.; Isgandar, H. Urban resilience: Multidimensional perspectives, challenges and prospects for future research. *Urban Gov.* **2024**, *4*, 162–179. [\[CrossRef\]](#)
2. Singh, B.; Jonas, A.E.G. Human-centered urban service design for an interconnected neighborhood(s) city. *Urban Geogr.* **2026**, *47*, 875–887. [\[CrossRef\]](#)
3. Li, Y.; Beeton, R.J.S.; Zhao, X.; Fan, Y.; Yang, Q.; Li, J.; Ding, L. Advancing urban sustainability transitions: A framework for understanding urban complexity and enhancing integrative transformations. *Humanit. Soc. Sci. Commun.* **2024**, *11*, 1064. [\[CrossRef\]](#)
4. Khan, I.A.; Haq, F.; Kiran, M.; Aziz, T. Circular economy and waste management: Transforming waste into resources for a sustainable future. *Int. J. Environ. Sci. Technol.* **2025**, *22*, 17327–17346. [\[CrossRef\]](#)
5. Mishra, V. Rethinking Urban Future: Towards Sustainable Cities and Communities. *Anthr. Sci.* **2025**, *4*, 91–98. [\[CrossRef\]](#)
6. Lieder, M.; Rashid, A. Towards circular economy implementation: A comprehensive review in context of manufacturing industry. *J. Clean. Prod.* **2016**, *115*, 36–51. [\[CrossRef\]](#)
7. Kirchherr, J.; Nadja Yang, N.-H.; Schulze-Spüntrup, F.; Heerink, M.J.; Hartley, K. Conceptualizing the Circular Economy (Revisited): An Analysis of 221 Definitions. *Resour. Conserv. Recycl.* **2023**, *194*, 107001. [\[CrossRef\]](#)
8. Aina, Y.A.; Almulhim, A.I.; Salami, B.A.; Swart, J.; Abubakar, I.R.; Dinis, M.A.A.; Sharifi, A. Trajectories of circular economy in cities: Key patterns and emerging pathways. *Cities* **2026**, *172*, 106852. [\[CrossRef\]](#)
9. Papadakis, D.M.; Savvides, A.; Michael, A.; Michopoulos, A. Advancing sustainable urban mobility: Insights from best practices and case studies. *Fuel Commun.* **2024**, *20*, 100125. [\[CrossRef\]](#)
10. Tunn, V.S.C.; Van Opstal, W.; Athanasopoulou, A. Sustainable mobility for whom? Tradeoffs and consumer segments on Mobility-as-a-Service platforms. *Sustain. Sci. Pract. Policy* **2026**, *22*, 2637306. [\[CrossRef\]](#)
11. Giuffrè, O.; Granà, A.; Giuffrè, T.; Acuto, F.; Lo Pinto, A. Life-cycle costing decision-making methodology and urban intersection design: Modelling and analysis for a circular city. In *Research Methods in Modern Urban Transportation Systems and Networks*; Lecture Notes in Networks and Systems; Macioszek, E., Sierpiński, G., Eds.; Springer: Cham, Switzerland, 2021; Volume 207, pp. 59–86. [\[CrossRef\]](#)
12. Shohet, I.M.; Levi, S.; Zeibak-Shini, R.; Shahin, F. Performance-Based Maintenance and Operation of Multi-Campus Critical Infrastructure Facilities Using Supply Chain Multi-Choice Goal Programming. *Appl. Sci.* **2025**, *15*, 11161. [\[CrossRef\]](#)
13. Mikolaj, J.; Remek, L.; Kozel, M.; Šedivý, Š. Maximizing Pavement Service Life: A Comprehensive Process Model Based on Structural Life Extension, Serviceability Deterioration Processes, and Asset Value. *Appl. Sci.* **2025**, *15*, 8782. [\[CrossRef\]](#)
14. Munonye, W.C. Towards Circular Economy Metrics: A Systematic Review. *Circ. Econ. Sust.* **2025**, *5*, 4093–4135. [\[CrossRef\]](#)
15. Kumar, C.R.; Kannan, B.; Keshavammaiah, P.H.; Parayitam, S. Public private partnership for the sustainable infrastructure development: A systematic literature review. *Qual. Quant.* **2025**, *59*, 2733–2751. [\[CrossRef\]](#)
16. Akbarieh, A.; Han, Q.; Klippel, A. Playing for a purpose: A systematic review and framework for gamified sustainability interventions in urban built environments. *Results Eng.* **2025**, *27*, 105277. [\[CrossRef\]](#)
17. Nosratabadi, S.; Mosavi, A.; Shamshirband, S.; Kazimieras Zavadskas, E.; Rakotonirainy, A.; Chau, K.W. Sustainable Business Models: A Review. *Sustainability* **2019**, *11*, 1663. [\[CrossRef\]](#)
18. Ricci, M.; Mosca, N.; Rafik, M.; Di Summa, M. How Extended Reality Is Shaping Smart Cities: A Systematic Literature Review. *Appl. Sci.* **2026**, *16*, 679. [\[CrossRef\]](#)
19. Cardoso Chrispim, M.; Mattsson, M.; Ulvenblad, P. The underrepresented key elements of Circular Economy: A critical review of assessment tools and a guide for action. *Sustain. Prod. Consum.* **2023**, *35*, 539–558. [\[CrossRef\]](#)
20. Teixeira, N. Circular economy perspectives: Challenges, innovations, and sustainable futures. *Discov. Sustain.* **2025**, *6*, 738. [\[CrossRef\]](#)
21. Independent Group of Scientists appointed by the Secretary-General, Global Sustainable. *Development Report 2023: Times of Crisis, Times of Change: Science for Accelerating Transformations to Sustainable Development*; United Nations: New York, NY, USA, 2023.
22. Elassy, M.; Al-Hattab, M.; Takruri, M.; Badawi, S. Intelligent transportation systems for sustainable smart cities. *Transp. Eng.* **2024**, *16*, 100252. [\[CrossRef\]](#)
23. Gu, Q.; Sing, M.C.P.; Jefferies, M.; Kanjanabootra, S. Bridging the gap between smart cities and sustainability: Current practices and future trends. *Cities* **2025**, *159*, 105799. [\[CrossRef\]](#)
24. de Abreu, V.H.S. Implementing Circular Economy Principles in Road Transport: Enhancing Efficiency to Mitigate Resource Depletion and Carbon Footprint. In *Carbon Footprint Assessments. Environmental Footprints and Eco-Design of Products and Processes*; Muthu, S.S., Ed.; Springer: Cham, Switzerland, 2024; Volume 1, pp. 289–312. [\[CrossRef\]](#)
25. Tumminello, M.L.; Macioszek, E.; Granà, A. Emerging Cutting-Edge Technologies and Applications for Safer, Sustainable, and Intelligent Road Systems in Smart Cities: A Review. *Appl. Sci.* **2025**, *15*, 11583. [\[CrossRef\]](#)
26. Grant, M.J.; Booth, A. A typology of reviews: An analysis of 14 review types and associated methodologies. *Health Inf. Libr. J.* **2009**, *26*, 91–108. [\[CrossRef\]](#) [\[PubMed\]](#)

27. Page, M.J.; McKenzie, J.E.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E.; et al. The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews. *PLoS Med.* **2021**, *18*, e1003583. [CrossRef] [PubMed]
28. Elsevier Scopus Database. Available online: <https://www.scopus.com> (accessed on 22 April 2026).
29. Thomson Reuters Web of Science Database. Available online: <https://www.webofscience.com> (accessed on 22 April 2026).
30. Google Trends. Available online: <https://trends.google.it/> (accessed on 22 April 2026).
31. Seo, K.H. Urban Resilience through Design: A Holistic Framework for Sustainable Redevelopment of Brownfield Sites. *J. Environ. Earth Sci.* **2025**, *7*, 395–413. [CrossRef]
32. Brozovsky, J.; Clauß, J.; Liu, P.; Healey-Brudal, T.T.; Yang, Y.; Healey-Brudal, Ø.; Li, J.; Li, B. A comparative analysis of climate friendly neighbourhoods in China and Norway: Insights on approaches, practices and policies from four case studies. *Energy Build.* **2025**, *335*, 115569. [CrossRef]
33. De Rosa, M.; Bianco, V.; Barth, H.; Pereira da Silva, P.; Vargas Salgado, C.; Pallonetto, F. Technologies and Strategies to Support Energy Transition in Urban Building and Transportation Sectors. *Energies* **2023**, *16*, 4317. [CrossRef]
34. Del Borghi, A.; Gallo, M.; Silvestri, N.; Baccelli, O.; Croci, E.; Molteni, T. Impact of circular measures to reduce urban CO₂ emissions: An analysis of four case studies through a production- and consumption-based emission accounting method. *J. Clean. Prod.* **2022**, *380*, 134932. [CrossRef]
35. Tsaligopoulos, A.; Kyvelou, S.S.; Chiotinis, M.; Karapostoli, A.; Klontza, E.E.; Lekkas, D.F.; Matsinos, Y.G. The Sound of a Circular City: Towards a Circularity-Driven Quietness. *Int. J. Environ. Res. Public Health* **2022**, *19*, 12290. [CrossRef] [PubMed]
36. Gravagnuolo, A.; Angrisano, M.; Girard, L.F. Circular economy strategies in eight historic port cities: Criteria and indicators towards a circular city assessment framework. *Sustainability* **2019**, *11*, 3512. [CrossRef]
37. Patnaik, B.C.M.; Satpathy, I.; Mandal, A. Circular Migration and Human Mobility—An Observation. *Mediterr. J. Social. Sci.* **2015**, *6*, 133–137. [CrossRef]
38. Anber, M.; Hafiz, E. The policy roadmap for achieving carbon-neutral, and green tourist cities under Egypt’s vision 2030: The Sharm El-Sheikh model, South Sinai. *Egypt. Front. Sustain. Cities* **2026**, *8*, 1780409. [CrossRef]
39. Soto, C.; Thomson, C.S.; Uti Nchor, J. Realizing the potential for circularity in Glasgow through the socio-spatial dimension of urban systems. *Build. Res. Inf.* **2024**, *52*, 957–983. [CrossRef]
40. Paoli, F.; Pirlone, F. Closing the City Cycle: An Approach for Defining Cross-Sectoral Circular Actions to Be Included in a Circular Urban Plan. *Sustainability* **2024**, *16*, 7747. [CrossRef]
41. Maillefert, M.; Serra, L. Understanding the driving forces behind the creation of territorial value. Towards a socio-territorial approach to urban functionalities. *Can. J. Reg. Sci.* **2025**, *48*, 7–14. (In French) [CrossRef]
42. Sharp, D.; Raven, R.; Farrelly, M. Pluralising place frames in urban transition management: Netzero transitions at precinct scale. *Environ. Innov. Soc. Transit.* **2024**, *50*, 100803. [CrossRef]
43. Moglia, M.; Frantzeskaki, N.; Newton, P.; Pineda-Pinto, M.; Witheridge, J.; Cook, S.; Glackin, S. Accelerating a green recovery of cities: Lessons from a scoping review and a proposal for mission-oriented recovery towards post-pandemic urban resilience. *Dev. Built Environ.* **2021**, *7*, 100052. [CrossRef]
44. Leturiondo-Aranzamendi, A.; De La Puerta-Rueda, I. Regional planning in Euskadi: Its contribution to a balanced and sustainable territorial and urban development. *Ciudad Y Territ. Estud. Territ.* **2021**, *53*, 867–884. (In Spanish) [CrossRef]
45. Duivenvoorden, E.; Hartmann, T.; Brinkhuijsen, M.; Hesselmans, T. Managing public space—A blind spot of urban planning and design. *Cities* **2021**, *109*, 103032. [CrossRef]
46. Crisostomi, V. Poster for the soft city. *Wit Trans. Ecol. Environ.* **2020**, *249*, 203–208. [CrossRef]
47. Xing, L.; Chau, K.Y.; Pan, S.-H.; Sadiq, M. Enhancing Circular Supply Chain Performance in Platform-Based Economies: The Role of AI, Blockchain Integration, and the IoT in Promoting Transparency. *Corp. Soc. Responsib. Environ. Manag.* **2026**, *33*, 2295–2312. [CrossRef]
48. Sahoo, S.; Kumar, S.; Vyas, M. How Does Blockchain Technology Contribute to the Development and Functioning of Smart Cities?—A Scoping Review and Future Research Directions. *J. Econ. Surv.* **2025**, *39*, 1907–1928. [CrossRef]
49. Pirrone, L.; Bionda, A.; Ratti, A. How Digital Technologies Can Support Sustainability of the Waterborne Passenger Mobility Ecosystem: A Case Study Analysis of Smart Circular Practices in Northern Europe. *Sustainability* **2024**, *16*, 353. [CrossRef]
50. Postorino, M.N.; Sarnè, G.M.L. Using Reputation Scores to Foster Car-Sharing Activities. *Sustainability* **2023**, *15*, 3295. [CrossRef]
51. Hatzivasilis, G.; Soultatos, O.; Ioannidis, S.; Spanoudakis, G.; Katos, V.; Demetriou, G. MobileTrust: Secure Knowledge Integration in VANETs. *ACM Trans. Cyber Phys. Syst.* **2020**, *4*, 33. [CrossRef]
52. Choudhuri, B.; Srivastava, P.R.; Mangla, S.K.; Kazancoglu, Y. Enterprise architecture as a responsible data driven urbandigitization framework: Enabling circular cities in India. *Ann. Oper. Res.* **2025**, *354*, 193–221. [CrossRef]
53. Pamučar, D.; Durán-Romero, G.; Yazdani, M.; López, A.M. A decision analysis model for smart mobility system development under circular economy approach. *Socio Econ. Plan. Sci.* **2023**, *86*, 101474. [CrossRef]

54. D'Amico, G.; Arbolino, R.; Shi, L.; Yigitcanlar, T.; Ioppolo, G. Digitalisation driven urban metabolism circularity: A review and analysis of circular city initiatives. *Land Use Policy* **2022**, *112*, 105819. [\[CrossRef\]](#)
55. D'amico, G.; Arbolino, R.; Shi, L.; Yigitcanlar, T.; Ioppolo, G. Digital technologies for urban metabolism efficiency: Lessons from urban agenda partnership on circular economy. *Sustainability* **2021**, *13*, 6043. [\[CrossRef\]](#)
56. Viglioglia, M.; Giovanardi, M.; Pollo, R.; Peruccio, P.P. Smart district and circular economy: The role of ICT solutions in promoting circular cities. *Sustainability* **2021**, *13*, 11732. [\[CrossRef\]](#)
57. McLean, L.; Roggema, R. Planning for a prosumer future: The case of central park, Sydney. *Urban Plan.* **2019**, *4*, 172–186. [\[CrossRef\]](#)
58. Di Marino, M.; Uteng, T.P.; Chavoshi, S.H.; Standal, A. Resharing the city: A framework for circular urban neighborhoods the case of Oslo. *Cities* **2026**, *171*, 106728. [\[CrossRef\]](#)
59. Uteng, T.P.; Di Marino, M.; Standal, A.K.; Grabalov, P. The Future of Resharing Practices in Norwegian Neighborhoods: Perspectives From Residents and Stakeholders. *Sustain. Dev.* **2025**, *33*, 9165–9179. [\[CrossRef\]](#)
60. Scavarda, A.; Daú, G.; Scavarda, L.F.; Duarte Azevedo, B.; Korzenowski, A.L. Social and ecological approaches in urban interfaces: A sharing economy management framework. *Sci. Total Environ.* **2020**, *713*, 134407. [\[CrossRef\]](#) [\[PubMed\]](#)
61. Sarfraz, M.; Gul, R.; Esztergár-Kiss, D. A Multi-Attribute Group Decision-Making Scheme Under q-Rung Orthopair Fuzzy Rough Aczel-Alsina Geometric Aggregation Operators with Applications in Sustainable Transportation. *Int. J. Comput. Intell. Syst.* **2026**, *19*, 54. [\[CrossRef\]](#)
62. Das, D.; Kalbar, P.P.; Velaga, N.R. Framework for Comparative Evaluation of Car-Sharing Alternatives for Urban and Suburban Regions: Case Study of Mumbai, India. *J. Urban Plan. Dev.* **2021**, *147*, 05021022. [\[CrossRef\]](#)
63. Husmann, J.; Beylot, A.; Ginster, R.; Spengler, T.S.; Herrmann, C. Determining the key drivers of the potential secondary batteryraw materials supply from the urban mine in the European Union. *Resour. Conserv. Recycl.* **2025**, *218*, 108246. [\[CrossRef\]](#)
64. Wiedenhofer, D.; Schug, F.; Gauch, H.; Lanau, M.; Drewniok, M.P.; Baumgart, A.; Virág, D.; Watt, H.; Cabrera Serrenho, A.; Tingley, D.D.; et al. Mapping material stocks of buildings and mobility infrastructure in the United Kingdom and the Republic of Ireland. *Resour. Conserv. Recycl.* **2024**, *206*, 107630. [\[CrossRef\]](#)
65. Wiedenhofer, D.; Baumgart, A.; Matej, S.; Virag, D.; Kalt, G.; Lanau, M.; Tingley, D.D.; Liu, Z.W.; Guo, J.; Tanikawa, H.; et al. Mapping and modelling global mobility infrastructure stocks, material flows and their embodied greenhouse gas emissions. *J. Clean. Prod.* **2024**, *434*, 139742. [\[CrossRef\]](#)
66. Frantz, D.; Schug, F.; Wiedenhofer, D.; Baumgart, A.; Virág, D.; Cooper, S.; Gómez-Medina, C.; Lehmann, F.; Udelhoven, T.; van der Linden, S.; et al. Unveiling patterns in human dominated landscapes through mapping the mass of US built structures. *Nat. Commun.* **2023**, *14*, 8014. [\[CrossRef\]](#) [\[PubMed\]](#)
67. Silvestri, L.; Forcina, A.; Silvestri, C.; Traverso, M. Circularity potential of rare earths for sustainable mobility: Recent developments, challenges and future prospects. *J. Clean. Prod.* **2021**, *292*, 126089. [\[CrossRef\]](#)
68. Amin, C.; Umrotun Fikriyah, V.N.; Samson, M.G.M. Livelihood vulnerability of urban waste pickers in Indonesia: Insights for inclusive circular economy transitions. *World Dev. Sustain.* **2026**, *8*, 100268. [\[CrossRef\]](#)
69. Khare, S.; Singhal, A.; Rallapalli, S.; Mishra, A. Bio-chelate assisted leaching for enhanced heavy metal remediation in municipal solid waste compost. *Sci. Rep.* **2024**, *14*, 14238. [\[CrossRef\]](#) [\[PubMed\]](#)
70. Balaguera, A.; Alberti, J.; Carvajal, G.I.; Fullana-i-Palmer, P. Stabilising Rural Roads with Waste Streams in Colombia as an Environmental Strategy Based on a Life Cycle Assessment Methodology. *Sustainability* **2021**, *13*, 2458. [\[CrossRef\]](#)
71. Carrasco-Bonet, M.; Fava, N.; González, S. Open Municipal Markets as Networked Ecosystems for Resilient Food Systems. *Sustainability* **2026**, *18*, 328. [\[CrossRef\]](#)
72. Cottyn, I.; Nijenhuis, G. Making a living between places: The role of mobility in livelihood practices in rural Rwanda. *Mobilities* **2022**, *17*, 136–151. [\[CrossRef\]](#)
73. Marome, W.; Rodkul, P.; Mitra, B.K.; Dasgupta, R.; Kataoka, Y. Towards a more sustainable and resilient future: Applying the Regional Circulating and Ecological Sphere (R-CES) concept to Udon Thani City Region, Thailand. *Prog. Disaster Sci.* **2022**, *14*, 1–13. [\[CrossRef\]](#)
74. Amasawa, E.; Kishita, Y.; Mohamed, A.F.; McLellan, B.; Kojima, M. Envisioning the Linkages Between Consumption and Production for Sustainability: Outcomes from Expert Workshops in Malaysia. *Circ. Econ. Sustain.* **2024**, *4*, 733–753. [\[CrossRef\]](#)
75. Almulhim, A.I.; Al-Saidi, M. Circular economy and the resource nexus: Realignment and progress towards sustainable development in Saudi Arabia. *Environ. Dev.* **2023**, *46*, 100851. [\[CrossRef\]](#)
76. Huss, A.; Peters, A.; Zhao, T.; Barouki, R.; Kogevinas, M.; Vermeulen, R.; Matthies-Wiesler, F. Setting the European environment and health research agenda –under-researched areas and solution-oriented research. *Environ. Int.* **2022**, *163*, 107202. [\[CrossRef\]](#) [\[PubMed\]](#)
77. Patel, S.J.; Patel, C.R. Prioritizing facilitators for successful implementation of PBSS in indian urban areas using BWM method. *Int. J. Math. Eng. Manag. Sci.* **2020**, *5*, 1108–1117. [\[CrossRef\]](#)
78. Christis, M.; Athanassiadis, A.; Vercalsteren, A. Implementation at a city level of circular economy strategies and climate change mitigation—The case of Brussels. *J. Clean. Prod.* **2019**, *218*, 511–520. [\[CrossRef\]](#)

79. Schröder, P.; Vergragt, P.; Brown, H.S.; Dendler, L.; Gorenflo, N.; Matus, K.; Quist, J.; Christoph, D.D.; Rupprecht, C.D.D.; Arnold Tukker, A.; et al. Advancing sustainable consumption and production in cities—A transdisciplinary research and stakeholder engagement framework to address consumption-based emissions and impacts. *J. Clean. Prod.* **2019**, *213*, 114–125. [\[CrossRef\]](#)
80. Dubresson, A.; Jaglin, S. Cities in french-speaking black Africa. The era of uncertainty | Villes et citoyens d'Afrique noire francophone. le temps des incertitudes. *Bull. D Assoc. Geogr. Fr.* **2010**, *87*, 15–25. [\[CrossRef\]](#)
81. Effendi, R.N.; Khodir, A.; Masudin, I. A QFD-PSS Approach to Designing Circular Economy-Based Sustainable Low-Carbon E-Bike Sharing Systems. *Circ. Econ. Sust.* **2026**, *6*, 48. [\[CrossRef\]](#)
82. Wüstenhagen, S.; Kirschstein, T. Substitution of Conventional Vehicles in Municipal Mobility. *Sustainability* **2024**, *16*, 6054. [\[CrossRef\]](#)
83. Pamucar, D.; Deveci, M.; Gokasar, I.; Işık, M.; Zizovic, M. Circular economy concepts in urban mobility alternatives using integrated DIBR method and fuzzy Dombi CoCoSo model. *J. Clean. Prod.* **2021**, *323*, 129096. [\[CrossRef\]](#)
84. Logan, S. The sub/urban fix. *Urban Geogr.* **2021**, *42*, 1033–1044. [\[CrossRef\]](#)
85. Scalisi, F. Use Infrastructures and the Design Evidence Link (DEL) for Urban Climate Mitigation: An Ex Ante and Ex Post Verification of User-Centred Mitigation Impacts. *Sustainability* **2026**, *18*, 3587. [\[CrossRef\]](#)
86. Roncero-Tarazona, M.; Ribó-Pérez, D.; Crespo-Montañés, C.; Pineda-Soler, J.; Gomar-Pascual, J.; Gómez-Navarro, T. Assessing urban climate actions: A quantitative pathway to decarbonisation. *Eng. Sci. Technol. Int. J.* **2026**, *77*, 102358. [\[CrossRef\]](#)
87. Suski, P.; Augenstein, K.; Greiff, K. Life Cycle Assessment of Consumption Patterns—Understanding links between social practices and environmental impacts. *J. Clean. Prod.* **2024**, *477*, 143813. [\[CrossRef\]](#)
88. Shams Esfandabadi, Z.; Ranjbari, M. Exploring Carsharing Diffusion Challenges through Systems Thinking and Causal Loop Diagrams. *Systems* **2023**, *11*, 93. [\[CrossRef\]](#)
89. Fishman, T.; Heeren, N.; Pauliuk, S.; Berrill, P.; Tu, Q.; Wolfram, P.; Hertwich, E.G. A comprehensive set of global scenarios of housing, mobility, and material efficiency for material cycles and energy systems modeling. *J. Ind. Ecol.* **2021**, *25*, 305–320. [\[CrossRef\]](#)
90. Takayama, Y.; Ikeda, K.; Thisse, J.-F. Stability and sustainability of urban systems under commuting and transportation costs. *Reg. Sci. Urban Econ.* **2020**, *84*, 103553. [\[CrossRef\]](#)
91. Dąbrowski, M.; Varjú, V.; Amenta, L. Transferring circular economy solutions across differentiated territories: Understanding and overcoming the barriers for knowledge transfer. *Urban Plan.* **2019**, *4*, 52–62. [\[CrossRef\]](#)
92. Gokasar, I.; Ozcan, E.; Deveci, M.; Tang, M. A Review on Sustainable Transportation and Circular Economy Actions on Urban Mobility. In *LISS 2023*; Gong, D., Ma, Y., Fu, X., Zhang, J., Shang, X., Eds.; Lecture Notes in Operations Research; Springer: Singapore, 2024; pp. 29–43. [\[CrossRef\]](#)
93. Daovisan, H. Responsible or Sustainable AI? Circular Economy Models in Smart Cities. *Sustainability* **2026**, *18*, 398. [\[CrossRef\]](#)
94. Sassaron, M.L.d.S.; Rodrigues da Silva, A.N.; Fonseca, F.; Rodrigues, D.; Ribeiro, P.J.G.; Nakata-Osaki, C.M. Combining Resilience and Sustainability in Urban Mobility: A Scoping Review and Thematic Analysis. *Land* **2025**, *14*, 2063. [\[CrossRef\]](#)
95. Kollár, V.; Matúšová, S. The Concept of Smart Cities—An Accelerator of the Circular Economy. In *Data-Centric Business and Applications*, 1st ed.; Lecture Notes on Data Engineering and Communications Technologies; Štarchoň, P., Fedushko, S., Gubíniová, K., Eds.; Springer: Cham, Switzerland, 2024; Volume 213, pp. 315–345. [\[CrossRef\]](#)
96. Sengupta, U.; Sengupta, U. SDG-11 and smart cities: Contradictions and overlaps between social and environmental justice research agendas. *Front. Sociol.* **2022**, *7*, 995603. [\[CrossRef\]](#) [\[PubMed\]](#)
97. Jayarathna, H.S.N.M.; Perera, B.A.K.S.; Atapattu, D.; Rodrigo, N. Circular economy and blockchain-integrated road map to improve construction waste management. *Constr. Innov. Inf. Process Manag.* **2025**, *25*, 23–49. [\[CrossRef\]](#)
98. Hanisch, M.; Goldsby, C.M.; Fabian, N.E.; Oehmichen, J. Digital governance: A conceptual framework and research agenda. *J. Bus. Res.* **2023**, *162*, 113777. [\[CrossRef\]](#)
99. Yildizbasi, A.; Celik, S.E.; Arioz, Y.; Chen, Z.; Sun, L.; Ozturk, C. Exploring the synergy between circular economy and emerging technologies for transportation infrastructure: A systematic literature review. *J. Clean. Prod.* **2025**, *486*, 144553. [\[CrossRef\]](#)
100. Ho, O.; Iyer-Raniga, U.; Sadykova, C.; Balasooriya, M.; Sylva, K.; Dissanayaka, M.; Sukwanchai, K.; Pal, I.; Bhatia, A.; Deepty Jain, D.; et al. A conceptual model for integrating circular economy in the built environment: An analysis of literature and local-based case studies. *J. Clean. Prod.* **2024**, *449*, 141516. [\[CrossRef\]](#)
101. Jegen, P.; Gast, L.; Faulstich, M. A review of the implementation of R-imperatives in circular construction. *Clean. Prod. Lett.* **2025**, *8*, 100097. [\[CrossRef\]](#)
102. Owais, M.; Mohammed, B.O.; Kamal, A.A.; Shaban, A.; Mostafa, A.H.; Hatem, K.; Emad, J.; Younis, S.T.; Ali, S.A.; Abdel-Hakim, A.E.; et al. Adaptive Traffic Signal Control Using Multi-Agent Reinforcement Learning: A Comparison of Control Strategies. *Sustainability* **2026**, *18*, 5702. [\[CrossRef\]](#)

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.