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EXTERNALITIES FOR BUSINESS DECISION MAKING OF CIRCULAR ECONOMY IMPLEMENTATION IN SMART CITIES

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Abstract
Externality is either an indirect cost or indirect benefit that is caused by one party but financially incurred or received by another. Externalities can be negative or positive. A negative externality is the indirect imposition of a cost by one party onto another. A positive externality, on the other hand, is when one party receives indirect benefit as a result of actions taken by another. For a successful business model of any publicly funded

project, direct and indirect benefits and costs must be fully established to derive a positive business case (e.g. based on benefit over cost ratio). This paper contributes to Eco4All by deriving new insights into the stakeholders' challenges, consumers' value chain, business processes and obstacles in the implementation of circular economy concepts within smart city environments. The main aim of the study is to determine externalities and enable the policies to implement a common circularity framework for inclusive application and assessment in smart cities to support decision-making for all value chain stakeholders and consumers enhancing the implementation level of the European Circular Economy Action Plan (ECEAP). Based on extensive industry expert interview, our new findings reveal the lack of value transfer across stakeholders and consumers, and there is an urgent need for more actionable and pragmatic solutions for circularity (including technology enabler, social value enabler, circular business model, human capability & behavior, and standard & legislation).
Keywords: externality, business model, circular economy, smart cities
JEL Classification: D62, Q51, Q56, R11, O18, L26

1. INTRODUCTION

Built environment sector and its supply chains contribute over 60% of total carbon emissions worldwide towards global warming. The built environment involves all aspects of our lives, encompassing the buildings we use and reside, the systems that distribute internet, telecommunication, water and electricity, and the roads, bridges, railways, airports, and other mobility systems we use to travel from place to another place. Generally, it is described as the man-made or constructed structures that enable living, working, travelling, and recreational spaces. Constructing, operating and maintaining all these spaces and systems requires enormous resources (i.e. materials, energy, fuel, labour, time, and money). In particular, the buildings are responsible for around 40% of energy and process-related carbon emissions. They consume 50% of all extracted (fossil) materials and 33% of water and then cause 35% of generated waste (European Commission, 2025a; 2025b). These combined actions can implicitly induce indirect environmental impacts including resource depletion, air, water and land pollution, environmental toxicity, habitat disruption and biodiversity loss. In fact, these will be exacerbated by the fact that the global population will increase nearly 30% to almost 10 billion on earth by 2025 with the exponential need for housing and urban development (Kaewunruen *et al*., 2016). Today, over 55% of the world's population lives in urban areas, and United Nation (2025) has also predicted that the urban population density is expected to increase to 68% by 2050. This implies that the problems will be tremendous if there is no solution to help the transition. In various countries, smart cities have been recently developed to digitally facilitate the urbanised built environment and improve the quality of live. However, neither are smart cities sustainable nor circular. On this ground, there is an urgent call for faster green transition of urban areas including smart cities to net zero and regenerative resources.

In recent years, European Green Deal has been introduced to offer a concerted strategy for a climate-neutral, resource-efficient and competitive economy (European Commission, 2025b). In order to achieve the net zero, circular economy (CE) principles have been a key instrument to drive the green transition. However, many challenges and barriers exist (across technical and scientific, economic, market, social and cultural, and regulatory aspects) against the implementation of circular economy for consumers and related stakeholders. A recent study revealed that consumers such as asset owners and managers are among the most influencers in decision making processes for circularity actions. However, the key concern of consumers is the financial burden and resource constraint due to the lack of sustained and viable business models for circular economy (Kaewunruen *et al*., 2024). A successful viable business model requires the thorough understanding and quantification of both cost(s) and benefit(s) over the whole lifecycle of the assets. At present, the cost and benefit are crudely estimated, resulting in miscalculation or misinterpretation of benefit over cost ratio (BBC, 2023). The issues are the lack of tools, methodologies and understanding into externality to derive benefit(s) and cost(s) for better and more informed decision-making mechanism. Externality is either an indirect cost or indirect benefit that is caused by one party but financially incurred or received by another. Externalities can be negative or positive. A negative externality is the indirect creation of a cost by one stakeholder onto another. In contrast, a positive externality is when a stakeholder earns an indirect benefit because of actions taken by another. Improving externalities can generate regional growth.

Accordingly, Eco4All Project has been established to promote green circular economy as a behaviour, by driving the actions and decisions of governments, companies, workers, citizens and consumers to realise their economic, environmental and social impacts in a responsible manner. This paper thus contributes to Eco4All by deriving new insights into the stakeholders' challenges, consumers' value chain, business processes and obstacles in the implementation of circular economy concepts within smart city environments. The main aim of the study is to determine externalities and recommend policies to implement a common circularity framework for inclusive application and assessment in smart cities to support decision-making for all value chain stakeholders and consumers enhancing the implementation level of the European Circular Economy Action Plan (ECEAP). The outcome of this study will address the business model challenges for smart built environments

2. CONCEPTS AND METHODOLOGY

We bring together a network of stakeholders with a significant impact on different life cycle stages of smart buildings and smart cities. Actors from multidisciplinary fields from two EU Cost Actions (Eco4All and CircularB) have been consulted to communicate to enhance circularity implementation in buildings constantly. Some stakeholders related to smart cities include:

a) Academia from different European universities with distinct expertise (Architecture, Construction Materials, Economics, Engineering, Management, Urban Planning, Smart Cities)
b) Research institutes currently working on smart cities, smart buildings, and circularity topics, such as assessment methods, efficient management, smart technologies of CDW, recycling and reuse, and design strategies
c) Practitioners, including smart building designers, contractors, consultants, material producers and supplier companies, waste management companies, and international environmental consultancy
d) National and local authorities and policymakers, including European municipalities; and,
e) National associations, including smart building and construction institutes, material producer representatives, professional associations, civil society, NGOs, etc.
f) By expert discussions within Eco4All & CircularB projects, the relationship among stakeholders and value chain consumers can be illustrated in Figure 1.

To conduct a critical literature review, keywords were derived from the research goal to facilitate the search for literature. The derived keywords were: 'Externalities', 'Circular Economy' and 'Smart Cities'. Additionally, when considering a CE implementation, it is often considered as a 'Business Model'. To the best of our knowledge, the study into externalities of circularity at the intersection of smart cities is relatively scarce, and our study is unprecedented.

Our research has then adopted a

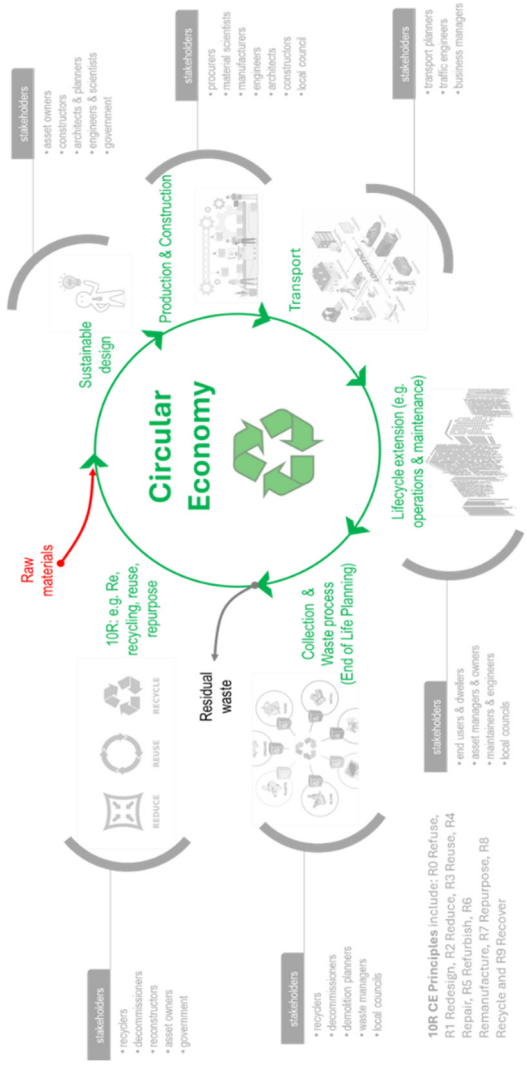

Figure 1. Stakeholders across different lifecycle stages of smart cities

qualitative approach via semi-structured interviews and dialogue with different stakeholders and consumers within a smart city environment (see Figure 2). The non-personal data was collected anonymously without withholding person information. All respondents had given consent for data collection. The data requested in this study was collected and processed by the researchers in accordance with the provisions of Regulation (EU) 2016/679 (the General Data Protection Regulation, GDPR) and all other applicable EU and UK privacy and data protection legislation. Open- end questions were asked to yield insights into the externalities of circular practices within smart cities**.**

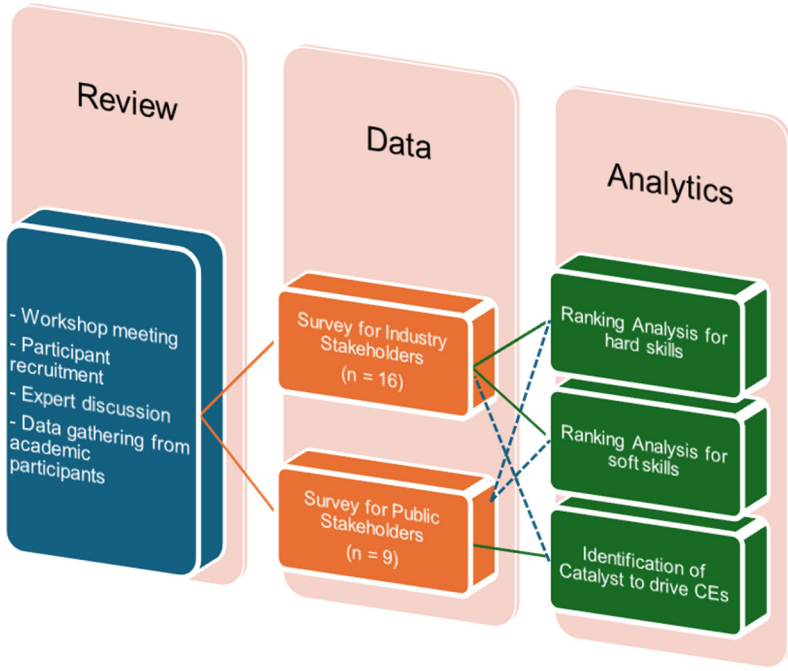

Figure 2. Research methodology

3. RESULTS AND DISCUSSION

Based on the expert interview, we have observed that the experts provided agreeable results. It is also noted that after 15-20 interviews, the experts' responses highly converge with very little variance. In Figure 3, the externalities observed by consumers and stakeholders for implementing circular practices in smart cities have been presented at different stages of life cycle. Green color implies indirect benefits and red implies indirect costs.

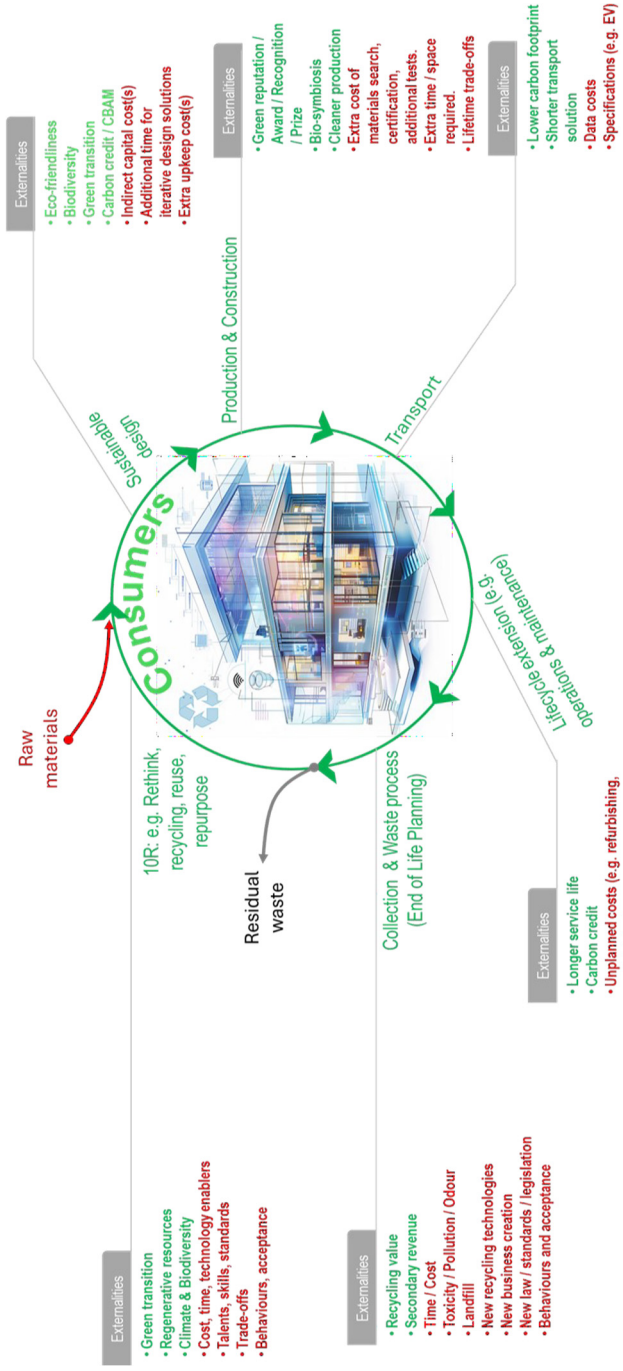

Figure 3. Circular externalities in the smart built environment

It is apparent that the common externalities for consumers are skills and capabilities, carbon credits or values, biodiversity conservation, and additional indirect costs for upkeep. The outcome also confirms previous findings by Neale *et al*. (2025) that future workforce must be highly collaborative and know how to engage industry, community and stakeholders. This resonates with a report by WEF – World Economic Forum (2025) that the most critical hard skill needed in 2030 are (i) artificial intelligence, (ii) digital engineering, and (iii) green transition / circular economy. Soft skills needed are (i) life-long learning and (ii) stakeholder engagement. This externality could be perceived as an indirect cost for consumers, but it can create new value and economy opportunities for other stakeholders (e.g. academic institutions, professional association, training centres, etc.).

According to a UK government report (2025), the carbon markets are not well established and do not currently reach their full potential. This is due to a lack of clarity among businesses and organisations on how carbon credits can be realised, and some poor practice affecting the effectiveness in delivering meaningful climate action and economic growth. There have been significant demands from businesses and organisations for greater clarity in how to use these carbon credit markets as part of their plans to reach net zero. This creates externalities (e.g. added value, new business opportunities, employment growth, etc.) for various stakeholders. The carbon credits derived from circular practices (e.g. the use of recycled materials, reused components, etc.) can generate indirect value and reputation to them. For example, these can help asset owners or investors achieve green building status and/or carbon neutrality, enhancing the assets' market value preposition, market penetration, brand and reputation. Note that the value of the global green economy has significantly increased from

$7.2tn in 2024 to nearly $8tn in 2025 (CRN, 2025). This indeed demonstrates the real use-case and industry demand for externality or indirect added value of circular economy practices.

The externality to biodiversity is invaluable. The circular practices generally help to escalate sustainable development of the built environment. However, there are two folds. Certain circular practices may reduce durability and service life of the assets while targeting at only environmental benefits. This action may not strike the balance for sustainability where all three pillars (including economic, social, and environmental pillars) should be considered. On this ground, European Commission (2025c) has launched "**Level(s)**" as an assessment and reporting tool for improving the sustainability performance of buildings. Level(s) has six macro-objectives, as shown in Table 1, to appropriately enrich circularity. In smart cities, these indicators are being monitored by sensors & IoT systems. The additional costs for digital technology enablers and relevant skills & capabilities have become an economic challenge for consumers but are new opportunities for research and new business.

Table 1. Level(s) for sustainable buildings (adapted from European Commission, 2025c and Bragança *et al*., 2025)

Level(s) macro objective	Indicators	Circular Practice
1. Greenhouse gas emissions along a buildings life cycle	• Use stage energy performance ($kWh/m^2/yr$) • Life cycle Global Warming Potential (CO_2 eq./m^2/yr)	R0 Refuse, R1 Redesign, R2 Reduce, R3 Reuse, R4 Repair, R5 Refurbish, R6 Remanufacture, R7 Repurpose, R8 Recycle and R9 Recover
2. Resource efficient and circular material life cycles	• Bill of quantities, materials and lifespans • Construction & Demolition waste and materials • Design for adaptability and renovation • Design for deconstruction, reuse and recycling	R0 Refuse, R1 Redesign, R2 Reduce, R3 Reuse, R4 Repair, R5 Refurbish, R6 Remanufacture, R7 Repurpose, R8 Recycle and R9 Recover
3. Efficient use of water resources	• Use stage water consumption (m^3/occupant/yr)	R0 Refuse, R1 Redesign, R2 Reduce, and R9 Recover
4. Healthy and comfortable spaces	• Indoor air quality • Time outside of thermal comfort range • Lighting and visual comfort • Acoustics and protection against noise	R0 Refuse, R1 Redesign, R2 Reduce, R3 Reuse, R4 Repair, R5 Refurbish, R6 Remanufacture, R7 Repurpose, R8 Recycle and R9 Recover
5. Adaption and resilience to climate change	• Protection of occupier health and thermal comfort • Increased risk of extreme weather • Sustainable drainage	R0 Refuse, R1 Redesign, R2 Reduce, R3 Reuse, R4 Repair, R5 Refurbish, R6 Remanufacture, R7 Repurpose, R8 Recycle and R9 Recover
6. Optimised life cycle cost and value	• Life cycle costs (€/m²/yr) • Value creation and risk factors	R0 Refuse, R1 Redesign, R2 Reduce, R3 Reuse, R4 Repair, R5 Refurbish, R6 Remanufacture, R7 Repurpose, R8 Recycle and R9 Recover

4. CONCLUSIONS

Circular business process and enablers driving consumers engagement for successful circular implementation in smart cities need to robustly realise both direct and indirect benefits(s) together with cost(s). Our study is the world's first to discover the externalities of circular practices at different stages of life cycle

throughout the asset's life. With the unified goal to promote greener transition, our study synergises and complements two EU Cost Actions: Eco4All (EU Circular Economy Network for All: Consumer Protection through reducing, reusing, repairing) and CircularB (Implementation of Circular Economy in the Built Environment) funded by European Cooperation for Science and Technology (COST).

Our study delves into the externalities by conducting rigorous open-end interviews with professionals and experts who have delivered smart cities. It is clear that consumers (or value chain stakeholders) face common externalities including skills and capabilities, realisation of carbon credits or values, biodiversity conservation, and additional indirect costs. The findings infer the common challenges and barriers for consumers to implement circular economy in practice. To overcome these challenges, the government and authorities must provide greater clarity for communicating and realising the externalities where businesses and consumers can both benefit from. It is critical to have the thorough understanding into the externalities and relevant stakeholders or consumers. This will help to facilitate essential relationship which underpins successful circular business model within the smart city environments, as illustrated in Figure 4. With these critical ingredients, the consumers will be protected and empowered to participate in the full circularity of the process.

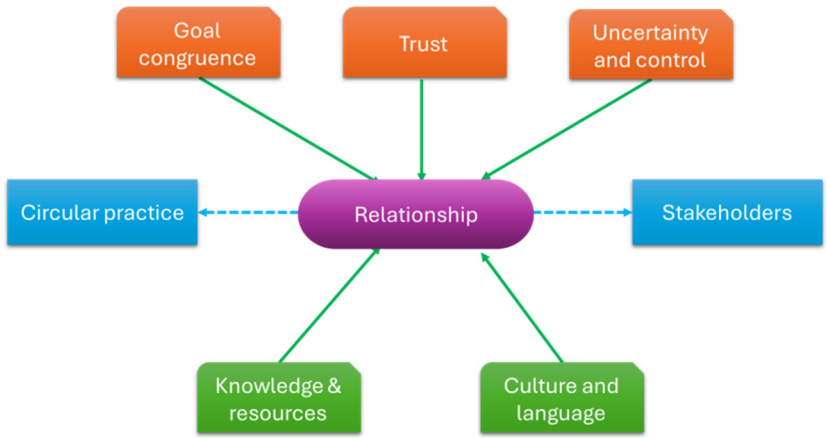

Figure 4. Critical ingredients to successful circular business model

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This volume brings together academic contributions and scientific abstracts presented at the ECO4ALL International Interim Conference (Iași, 9–10 May 2025), organized within the framework of the COST Action CA22124 – ECO4ALL. The papers explore current topics regarding the consumer-centric circular economy, such as extended producer responsibility, cross-border consumer protection, green public procurement and legal regulations for sustainability. The volume reflects an interdisciplinary vision and contributes to shaping a common European agenda for the green transition.

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