

Target Areas for Climate Action Via Urban Circular Bioeconomy in Ireland: Built Environment, Food, Manufacturing, Transport & Logistics, And People

¹Zimmermann Sarah

²Holden Nicholas M.

³Downey Claire

¹PhD Research Officer, The Rediscovery Centre, The Boiler House, Ballymun Main Street, Ballymun, Dublin 9, Ireland D09 HK58

²Professor of Biosystems Engineering, BiOrbic Bioeconomy Research Ireland Research Centre and UCD School of Biosystems and Food Engineering, University College Dublin (UCD), Belfield, Dublin 4, Ireland D04 VIW8

³Chief Executive Officer, The Rediscovery Centre, The Boiler House, Ballymun Main Street, Ballymun, Dublin 9, Ireland D09 HK58

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*Corresponding author: Zimmermann Sarah, PhD Research Officer, The Rediscovery Centre, The Boiler House, Ballymun Main Street, Ballymun, Dublin 9, Ireland D09 HK58; Email: sarahz@rediscoverycentre.ie

Abstract

The work summarised in this paper was undertaken to deliver a fast-track to policy report for the Environmental Protection Agency in Ireland. The objective was to identify readily adoptable climate change mitigation opportunities in the context of urban circular bioeconomy. The circular economy and bioeconomy are central to delivering climate action and resource efficiency as part of the EU Green Deal. Cities and urbanised areas have an important role in this context, given their densities and scale, in terms of people, businesses, and high levels of resource consumption and waste generation. The initial review of evidence indicated that actions could most effectively be structured under five themes: (1) circular built environment, (2) circular food system, (3) circular manufacturing, (4) transport and logistics and (5) uptake of circular consumer goods. Implications for Ireland were identified based on literature, and example case studies that could be put into action quickly, with a high chance of success were identified. These focussed on bio-based construction materials, joining the organic cities network, optimising local supply chains, zero emissions logistics and utilising toolkits for resource management in local authorities. It was concluded that there is great potential for Ireland to rapidly adopt case studies developed in the European Union to achieve climate mitigation through urban circular bioeconomy.

Keywords: urban circular bioeconomy, climate action, target areas for action

Introduction

Greenhouse gas emissions continue to increase and drive global warming owing to unsustainable patterns of energy use, land use, production and consumption (IPCC, 2023). In response to this crisis, the Government of Ireland declared a climate emergency in 2019, and the Climate Action and Low Carbon Development (Amendment) Act 2021 provides the governance framework for achieving greenhouse gas emission (GHG) mitigation targets, namely a 51% reduction by the end of 2030 relative to 2018 levels and net zero by 2050.

Despite these legally binding commitments, according to the national Climate Change Assessment Synthesis Report 2023 Ireland is not on course to meet its 2030 and 2050 GHG reduction targets. Annual carbon budget reviews for 2021 and 2022 indicated that 47% of Ireland's first carbon budget (2021 - 2025) had been emitted within 40% of the budget time frame. Greater emphasis on systemic transformation is needed, along with more effective implementation of improved policies. Consideration of alternative economic models is noted as a key aspect of achieving systemic change and addressing indirect drivers of emissions (Thorne et al., 2023). Ireland's small, open, highly globalised free market economy currently ranks 3rd on the Index of Economic Freedom (<https://www.heritage.org/index/>). In this context, alternative economic model development to meet climate change challenges requires systemic transformation driven by a range of legal, economic, cultural, technological and skills interventions (Circle Economy, 2024; Joint Committee on Environment and Climate Action, 2024).

There is significant potential for a circular economy to drive systemic economic change and mitigate climate change using supply and demand side interventions aimed at decoupling material use from economic growth (Chepeliev et al., 2026). Corvellec et al. (2022) highlight some problems with circularity however, such as an oversimplification of cyclical systems, resource efficiency rebound effect (i.e. reduced costs can increase consumption), challenges with connecting waste streams and secondary resources to production, biophysical limits to economic growth and neglect of circular economy impact assessments on society and the environment. Better integration of energy-climate mitigation modelling and circular economy analytical tools (e.g. material flow analysis) would capture the contribution of materials' circularity to climate change mitigation (Lima et al., 2023). A more recent review of the links between circular economy approaches and climate change mitigation demonstrates that circular economy can reduce greenhouse gas emissions with support from a robust enabling policy and governance framework, financial incentives, cross-sectoral collaboration and the adoption of appropriate digital tools (Ijimdiya et al., 2026).

Bioeconomy is also thought to offer significant climate change mitigation potential. Biomass is organic material of biological origin that can potentially be carbon-neutral, when compared to the release of carbon from fossil fuels (Lewandowski et al., 2018). In relation to climate change mitigation, products and materials derived from wood, for example, can be used as alternatives to concrete and steel products with a relatively higher carbon footprint (Hetemäki and Kangas, 2022). The substitution effect is dependent however on the lifetime and GHG emissions of the substitution product (EEA, 2023). Circular bioeconomy is the melding of circular economy and bioeconomy to achieve efficient and circular bio-resource management (Tan and Lamers, 2021). In the context of the bioeconomy, circularity refers to both the cycle of technical materials and a regenerative cycle of materials to support ecosystem restoration and function (EEA, 2018; EMF, 2019). According to Sharma and Malaviya (2023), the circular bioeconomy can support the achievement of 17 Sustainable Development Goals and 134 targets of the Sustainable Development Agenda 2030. Another review of research relating to how circular economy and bioeconomy contributes to achieving the SDGs reveals a disparity between the SDG priorities of both approaches and recommends circular bioeconomy as a means to achieve all SDGs (Ferraz and Pyka, 2023).

To date, bioeconomy development in Ireland has focussed on diversifying the agricultural sector given that 65% of land is under some form of agricultural practice that collectively accounts for 38% of territorial GHG emissions (Circle Economy, 2024). The urban perspective is vitally important however, given that 46% of the Irish population live in cities and the high per-capita consumption level (Circle Economy, 2024). Cities and urbanised areas consume and generate large amounts of biological resources, which is particularly important in Ireland given the spatial distribution of population and bias towards the greater Dublin area and other towns and cities. Urban circular bioeconomy development is important for driving systemic economic change and climate action, given the high levels of biomass consumption and waste production concentrated in densely populated urban areas and the increasing levels of urbanisation. In addition, circular use of biomass in urban areas can stimulate the national bioeconomy, and urban-derived biomass can contribute to bioeconomy material flows. Sekabira et al. (2023) note that "... circular bioeconomy can serve as a bridge to both urban and farming communities...", so urban circular bioeconomy must always be viewed in the wider geographical context. In fact, it has been stated that urban circular bioeconomy development can strengthen urban to rural linkage and help meet rural regeneration goals (Philip and Winickoff, 2018).

Ireland differs from most of the European Union member states because it is physically isolated at the end or beginning of supply chains, requiring sea transport to connect to the single market. The responsibility for implementing change in urbanised areas has been placed in the hands of local authorities (county and city councils) that are mandated to develop and manage such areas. They are obliged to prepare Local Authority Climate Action Plans every five years in line with the governance framework and to identify Decarbonising Zones (DZ) as demonstration sites for targeted, innovative measures. Climate Action Regional Offices are working with local authorities to deliver their climate action plans at the regional and local levels. Key questions for the wider public service is what action to take under specific circumstances, and in the context of legal emissions reductions, what can be learned from the wider European context that could enable rapid success?

The work summarised in this paper was undertaken to deliver a fast-track to policy report for the Environmental Protection Agency in Ireland. The objective was to identify readily adoptable climate change mitigation opportunities in the context of urban circular bioeconomy. The research summarised here focused on:

- Identifying urban circular bioeconomy opportunities for climate action within the context of specific circular economy pathways for climate action.
- Collating best practice in urban circular bioeconomy using case studies selected because they could be rapidly deployed in Ireland.
- Providing urban bioeconomy policy recommendations for future revisions of the national Bioeconomy and Climate Action Plans.

Methods

The approach taken for this fast-track to policy research was to (1) summarise key concepts and literature about urban circular bioeconomy (briefly summarised above in the introduction); (2) use the literature to identify target pathways towards climate mitigation through urban circular bioeconomy; (3) review research conducted in the European Union and select case studies to illustrate readily deployable actions (for Ireland).

The Circularity Gap Report Ireland (Circle Economy, 2024) commissioned by the Department of Environment, Climate and Communications identified five target circular economy pathways that have the potential to reduce Ireland’s carbon emissions by up to 32 per cent. The five target areas are: (1) circular built environment, (2) circular food system, (3) circular manufacturing, (4) transport and logistics and (5) uptake of circular consumer goods. Urban circular bioeconomy opportunities for climate change mitigation were identified for each of the five target areas. It was decided that these should be used to structure the case studies and policy recommendations because no literature was found that contradicted this framing, which used concepts and terminology familiar to the target audience for the fast-track to policy report. For each target area, the specific climate challenge for Ireland was identified and summarised, its primary urban context defined, along with urban circular bioeconomy opportunities for mitigation (all based on the foundation of peer-reviewed literature and reports).

The case study selection criteria were: (1) had to be an ongoing or complete EU-based projects led by an institution based outside of Ireland (2) relevant to urban areas (3) focused on urban areas of similar size and structure to Irish cities if possible and (4) representative of circular bioeconomy, the cascading use of biomass or optimising the value of bio-based products, materials and resources over time; and (5) to derive policy recommendations based on the findings.

Results

Table 1 presents climate challenges, the urban perspective and opportunities for climate change mitigation for the five circular economy target areas. For each target area a case study with potential for rapid deployment in Ireland was identified, as outlined in Table 2. Each case study was considered in terms of relevance for the target area and implications for implementation in Ireland (note, the results presented here only summarise the case studies that were considered most relevant for the fast-track to policy report and the target audience).

It should be noted that these recommendations were limited to high level implications as the fast-track to policy report was intended to provide policy makers with diverse backgrounds and mandates to be able to work from a coherent foundation and body of evidence. The authors had no authority, mandate or formal role in national or local policy making in practice.

Table 1: Climate challenges, urban context and opportunities for climate change mitigation for five circular economy target areas

Target Area	Climate challenge in Ireland	Urban context	Urban circular bioeconomy opportunities for climate change mitigation
Circular built environment	Built environment and construction account for 37% of Ireland’s national emissions (14% Embodied Carbon; 23% Operational Emissions) (IGBC, 2025). Retrofit target of 500,000 homes in Ireland by 2030 (Climate Action Plan, 2024).	High building density	<ul style="list-style-type: none"> Accelerate the use of biobased construction and retrofitting materials to replace carbon-intensive materials (e.g. cement, concrete, steel) (Hertwich et al., 2019; Ding et al., 2022; Bošković & Radivojević, 2023; EEA, 2023; Daly and Barril, 2024 a,b)
Circular food systems	Annual food waste per person (145kg) is higher in Ireland than the EU average. In 2023, 169,864 tonnes of biodegradable municipal waste were disposed of in landfill, representing 32.6% of all municipal waste sent to landfill (epa.ie). Landfilling such organic wastes generates significant GHG emissions (Nordhal et al., 2020). Urban areas typically depend on long, complex food supply chains.	High levels of food consumption and food waste generation; Ireland has one of the lowest numbers of community gardens and allotments in the EU (cgireland.org).	<ul style="list-style-type: none"> Reduce food waste (Mohareb et al., 2018) Improve the segregation and capture of organic waste and diversion from landfill (Zero Waste Europe, 2024). Increase urban and peri-urban agriculture as part of biodistrict development, with a focus on agroecology and local food value chains, events and markets (Kulak et al, 2013; organicseurope.bio). Integrate Urban Wastewater Treatment as part of nutrient recovery (Aryaampa et al., 2025)
Circular manufacturing	In 2023, emissions from manufacturing combustion accounted for 7.6% of Ireland's total GHG emissions (epa.ie). Manufacturing in Ireland represents 20% and 17% of the material and carbon footprint, respectively (Circle Economy, 2024).	Urban-based manufacturing facilities are typically located in peripheral industrial estates	<ul style="list-style-type: none"> Embed renewable energy within circular manufacturing (Posen et al., 2017). Boost industrial symbiosis, i.e. the association between manufacturing facilities in which waste or by-products of can become feedstocks in another (Bijon et al., 2022)
Redesign transport & mobility	Heavy-duty vehicles, largely diesel-fuelled, increased by 177% between 1990 and 2023. Commercial transport emissions require decoupling from economic activity via sustainable planning and electrification (www.epa.ie)	Urban-based businesses within circular bioeconomy supply chains	<ul style="list-style-type: none"> Develop national and regional circular bioeconomy value and supply chains (Beames et al., 2021) Apply the VECTO tool to assess transport-related GHG emissions and promote the use of zero-emission alternatives (Middela et al., 2024).
Circular consumption	In 2023, Ireland’s Actual Individual Consumption per capita (goods and services consumed by households) was 94%, ranking 7th out of 27 Member States. High material consumption is a driver of increasing waste levels and GHG emissions. (Circle Economy, 2024)	Urban-oriented campaigns are important for reducing overall consumption and bioeconomy market development owing to high population density.	<ul style="list-style-type: none"> Promote sufficiency lifestyles and local, circular biobased products (Circle Economy, 2024). Embed Green Public Procurement in the public sector.

Table 2: Case studies for each target area with potential for rapid deployment in Ireland

Target Area	Case study	Relevance	Implementation in Ireland
Circular built environment	Built by Nature – accelerating the timber building transformation (ongoing since 2021) (https://builtbn.org/)	Built by Nature (BbN) demonstrates how an innovative grant-making network of investors, foresters, developers, asset owners, designers, cities, insurers and governments can drive the sustainable use of timber and other bio-based materials as alternatives to concrete and steel in the building sector via a Connect-Enable-Amplify model.	Ireland has the infrastructure to implement the BbN approach with little modification through the The Irish Green Building Council (IGBC), a non-profit organisation providing leadership across the built environment value chain.

Circular food systems	Organic City (BioStadt) Bonn, Germany – Organic Cities Network (2015 - present) (https://www.organic-cities.eu/)	The Organic Cities Network Europe, established in 2015, fosters organic agriculture and organic food as part of the overarching EU Common Agricultural Policy Network. Organic cities promote bioeconomy and climate action by focussing on renewable resources, reducing waste, fostering bio-based industries and reducing the application of synthetic nitrogen fertilisers.	There has been significant growth in organic farming in Ireland since 2021, and the aim is to have 10% of land under organic farming by 2030. Membership of the Organic Cities Network Europe would support Ireland’s National Organic Strategy 2024 - 2030 by building demand for domestically-produced organic products and enable achievement of the target for public sector bodies to spend a minimum of 10% organic food by value under its Green Public Procurement Strategy and Action Plan 2024-2027. The Organic Cities Network can also drive green procurement in the private sector and support compliance with the EU Corporate Sustainability Reporting Directive.
Circular manufacturing	SYMBA - Securing Local Supply Chains via the Development of New Methods to Assess the Circularity and Symbiosis of the Bio-based Industrial Ecosystem (2024 - 2026) (https://www.symbaproject.eu/)	The EU Horizon SYMBA project brings together a consortium of 9 partners from 5 EU countries (Italy, Spain, Belgium, the Netherlands and Germany) to deliver resource efficiency as part of circular bio-based industrial value chains. The project is developing a novel AI-driven Industrial Symbiosis (IS) tool tailored to local and regional bio-based ecosystems and replicable across the EU.	CIRCULÉIRE’s Thematic Working Group Industrial Symbiosis Synthesis Report 2020 provides insights into the Industrial Symbiosis landscape in Ireland. The key recommendations for fostering industrial symbiosis in Ireland relate to technologies, end of waste, networks and data. The overarching recommendation is for a facilitated industrial symbiosis programme comprising a government owner or sponsor, a national coordinating body for delivery and an innovation/research partner.
Redesign transport & mobility	CITYLAB – Incubating zero-emission logistics in living laboratories (2015 – 2018) (https://civitas.eu/projects/citylab)	Innovative urban and regional transport management is an important aspect of minimising carbon emissions in circular bioeconomy supply chains. With regard to the urban context, the CITYLAB project developed a range of strategies, actions and tools for zero-emission logistics in ‘Living Labs’ located in Rotterdam/Amsterdam (the Netherlands), Brussels (Belgium), London (United Kingdom), Oslo (Norway), Paris (France), Rome (Italy) and Southampton (UK).	Bioeconomy supply chain development in Ireland can include innovative urban and regional transport management.
Circular consumption	HOOP - Vitalise Europe’s Urban Bioeconomy (2021 - 2025) (https://hooproject.eu/)	The project developed urban circular bioeconomy initiatives across the 8 Lighthouse cities and delivered Project Development Assistance (PDA) for the production of bio-based materials such as fertilisers and bio-plastics from urban biowaste and wastewater in each city, with a focus on cross-cutting technological innovation, regulation, market development, public procurement and stakeholder engagement.	Circular Bioeconomy Cluster is a member of the HOOP Network of Cities and Regions and supports the CircBioCityWaste project (2022 - 2026) (https://circbio.ie/projects/national/circbiocitywaste/), which aims to develop an integrated biorefinery for valorising anaerobically digested sludge from municipal organic waste, wastewater treatment sludge and dairy processing waste. The application of the HOOP toolkit to Local Authority Decarbonising Zones can help to raise awareness of the bioeconomy, reduce food waste and improve the segregation and capture of municipal organic waste from homes and businesses.

Key national policy recommendations for each target area

Circular built environment

- Reducing the costs/green premium of bio-based construction materials will increase their use and accelerate the replacement of carbon-intensive materials such as concrete and cement. Funding model options include a government fund, a public-private partnership model similar to Peatland Finance Ireland or a philanthropic fund supported by industry. A range of policy actions to accelerate the use of bio-based construction and retrofitting materials to replace carbon-intensive materials is presented in *Building a Circular Ireland - A Roadmap for a Resource Efficient Circular Built Environment* (IGBC, 2025)
- Pursue National Standards Association of Ireland (NSAI) Agreement Certification for bio-based construction materials and set targets for the use of such materials in

local authority construction and retrofitting, in line with the National Retrofit Plan and as part of a public procurement strategy for bio-based construction materials.

• Circular food systems

- Membership of the Organic Cities Network Europe would support Ireland’s National Organic Strategy 2024 - 2030 and enable achievement of the target for public sector bodies to spend a minimum of 10% organic food by value under its Green Public Procurement Strategy and Action Plan 2024-2027.
- Reduce food waste (commercial and residential) and improve organic waste segregation and capture in urbanised areas using the EU HOOP project toolkit and other regulatory measures.
- As part of biodistrict development, support implementation of the Planning and Development Act 2024 requirement for LAs to reserve land for use and cultivation as allotments and prescribed community gardens and the regulation, promotion, facilitation or control of the provision of land for that use.

Circular manufacturing

- Bioeconomy manufacturing facilities need to maximise the use of on-site renewable energy and resource efficiency measures, such as energy and water meters. Enterprise Ireland, the Sustainable Energy Authority of Ireland and CIRCULEIRE offer a range of relevant support to manufacturers.
- Bio-product design must adopt circularity as a core principle.
- Apply industrial symbiosis tools, such as those under development as part of the SYMBA case study, to a bio-industrial network as part of a national industrial symbiosis programme. Tools should build on learnings from the SMILE Resource Exchange (https://ec.europa.eu/regional_policy/en/projects/europe/smile-saving-money-reducing-waste-and-creating-business-opportunities), which has been implemented in Ireland in Cork and Dun Laoghaire-Rathdown already.

Redesign transport and logistics

- Increase funding for regional bioeconomy clusters to develop local circular bioeconomy supply chains. Supply chain development can be informed by the EU CITYLAB project, which has produced a range of strategies, actions and tools for zero-emission logistics.
- Assess transport emissions within bioeconomy supply chains using existing tools, e.g. VECTO, and incentivise the use of smaller, lightweight vehicles, electric vehicles and low-carbon fuels where appropriate.

Circular consumption

- The National Circular Economy Communications & Public Engagement Platform provides an excellent opportunity for the promotion of sufficiency lifestyles and local, circular biobased products via an urban circular bioeconomy communications plan that embraces and celebrates urban and rural linkages. The communication plan can be informed by the BioBeo education programme (<https://www.biobeo.eu/>) and EU HOOP project toolkit, which provides a range of public engagement resources for boosting citizen awareness of urban circular bioeconomy.
- Embed effective Green Public Procurement throughout the public sector as a circular bioeconomy market pull measure in accordance with Circular 17/2025 regarding Green Public Procurement obligations.

Discussion

There is significant potential to deliver climate action through urban circular bioeconomy development within the context of circular economy target areas, namely circular built environment, circular food systems, circular manufacturing, transport and logistics and uptake of circular consumer goods. Climate mitigation management for urban areas in Ireland should utilise the revised EU Bioeconomy Strategy to support the development of towns and cities as major circular bioeconomy hubs. To make this work, material flow analysis is needed as an integral aspect of local bioeconomy development and climate action. Data and pathway maps of mass flowing through the system will be critical information for local authorities to successfully manage urban bioeconomy for climate mitigation. Coordination of the Urban Circular Bioeconomy Strategies with the Circular Cities and Regions Initiative should help to improve circular economy and bioeconomy policy coherence and implementation.

As noted by the European Investment Bank Group, the lack of investment in circular bioeconomy infrastructure inhibits the further development of innovative solutions. The policy recommendations presented in this report must be underpinned by long-term funding and financial incentives to develop markets for bio-based construction materials and organic products, improve organic waste segregation and capture, and increase the number of community gardens and allotments. Policy interventions must also build consumer awareness of the value of bio-based products and deliver robust green public procurement as market pull measures. Circular bioeconomy development in Ireland is best served by a systemic, holistic approach that avoids integrates 'urban' and 'rural' contexts given their interdependence.

An immediate action is for at least one Irish city pilot for each of the target areas identified to be implemented so as to serve as a city-wide, long-term demonstration initiative of circular economy and bioeconomy actions. Support and (perhaps more importantly) funding for local authorities to deliver circular bioeconomy-related actions will be essential as these actions are unlikely to happen within the constraints of day-to-day operational budgets. Research to develop and monitor the role of circular bioeconomy in local authority decarbonisation zones, with a focus on food, organic waste, construction and natural capital will also be essential.

Conclusion

In conclusion, this research provides policy makers in Ireland charged with developing national climate and bioeconomy actions strategies and plans with a range of urban circular bioeconomy climate change mitigation opportunities. The circular economy framing of the opportunities can help improve policy cohesion with the bioeconomy and broader adoption of circular bioeconomy principles. While this research places a needed spotlight on the urban and circular perspective of bioeconomy, circular bioeconomy development should focus on material flows and value chains as part of a systems-based approach that embraces both urban and rural contexts.

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