Improving policy coherence for circular cities
Evaluating circular built environment policies of London and Amsterdam

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Improving policy coherence for circular cities

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by

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Summary

This dissertation aims to contribute to the urgent need for a circular city policy evaluation framework in European cities. By bridging the concepts of circular cities, policy coherence and policy evaluation, this dissertation provides an ex-ante policy evaluation tool, namely the circular city policy coherence framework.

The concept of a circular city is inspired by biological metabolic systems and aims to implement circular economy principles in various aspects of urban functioning, i.e. to minimise the consumption of primary resources and energy, thereby reducing environmental impacts such as waste and emissions. This approach involves redefining urban processes to close, narrow and slow down material and energy flows.

The built environment is included as an area of intervention in most European circular city policies following it is a major resource consumer and polluter through construction and demolition. These policies generally promote a circular built environment by replacing primary raw materials with at least secondary ones, standardising circular practices in design, construction and deconstruction, creating markets for secondary resources and sharing knowledge to integrate circular practices into construction value chains.

However, there are two issues that make the evaluation of circular city policies, and those specific to the built environment, difficult. On the one hand, there is the issue of process: most circular city policies have been in place for less than a decade, and the scale of the built environment makes any policy aimed at changing it a long-term one, making ex-post evaluation impractical today. On the other hand, there is the issue of content: the lack of clear and commonly used conceptualisations of circular cities hampers policy (evaluation) frameworks. Therefore, the aim of this dissertation is to explore the extent to which circular built environment policies contribute to the policy ambitions formulated by cities. This leads to the main research question:

To what extent do circular built environment policies contribute to policy ambitions as formulated by cities?

To answer this research question this dissertation is structured as five independent, but related academic studies.

The first study explores the recent conceptualisation of circular cities as found in the academic literature. It introduces the concept of circular economy and the application of circularity at different levels of the built environment. It then provides a historical narrative from the study of urban metabolism as the dominant analytical lens to the more recently developed understanding of a circular city. Existing perspectives and conceptualisations of the circular city as well as current bibliometric trends are presented.

The second study presents the relationship between a circular built environment and the policy instruments for its implementation as discussed in the academic literature. This is done through a systematic literature review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. It analyses over 140 articles in terms of circular urban development policies (i.e. circularity, ecological regeneration and adaptation) and policy instruments (i.e. regulatory, economic and information).

The third study proposes the ex-ante circular city policy coherence framework. The framework, resulting from the combination of two existing frameworks for policy coherence analysis and circular city development, is tested using the case study of the Delft University of Technology campus development as an urban development proxy.

Based on document analysis of spatial development and circular economy policies, the fourth study uses the ex-ante circular city policy coherence framework to evaluate the policy coherence - or (mis)alignment and potential synergies - of circular built environment policies in Greater London. The Greater London Authority (GLA) presents an interesting case for examining policy coherence of circular built environment policies due to its authority, governance structure, scale and the notable gap in governance research that has not been fully explored.

The fifth and last study examines an ex-ante policy evaluation of timber construction in Amsterdam, the Netherlands, given its decade-long circular city policy and recent ambitions for mass timber construction. This is done in two steps. Firstly, policy instruments from different policy documents in Amsterdam were identified and analysed in terms of how they aim to contribute to a more circular built environment. Secondly, an agent-based model was built as a tool for policy makers to simulate the emergent interactions and outcomes of selected policy instruments in increasing timber construction in Amsterdam.

Conclusions and implications

This dissertation concludes that the current understanding of a circular built environment does not see the city for the buildings. By advancing a perspective on circularity in the built environment based on the concept of circular cities, this dissertation proposes that while circular built environment policies have improved their overall coherence, particularly through business-led optimisations in construction practices, they fall short of fully realising a circular city as envisioned by the circular city policy coherence framework. The circular built environment policies of London and Amsterdam are increasingly designed to mitigate issues such as resource depletion and waste generation. However, their policies largely overlook a broader, more systemic approach, particularly in terms of assessing the need for new buildings, maintaining and adapting the existing building stock, and involving residents and communities in the development of a circular city.

The main contribution of this dissertation is to problematise circular built environment policies in relation to circular cities, with a pioneering evaluation of such policies in London and Amsterdam. It positions the built environment as a key component of circular cities, highlighting the influence of policy decisions on the design of the built environment. The work includes the first systematic literature review of policy instruments for circular built environments, identifying a technocratic trend and a focus on looping measures. It also presents an ex-ante policy evaluation framework for circular cities, tested in Amsterdam and London, which allows the assessment of policy coherence and potential impacts, complemented by an agent-based model to visualise interactions and emergent properties between policy instruments.

The circular city policy coherence framework is currently the only one (to the best of the author's knowledge at the time of writing) that not only integrates both process and content aspects within circular city policies, but also allows for the analysis of policy alignment and synergies between different urban policy areas.

Policy makers could use this framework to design more ambitious and well-rounded policies that include all three circularity actions. The policy coherence factors would provide the necessary justification to refine existing policy objectives and instruments or to propose new ones for future implementation, as well as to detect where or how a more systemic perspective of a circular city can improve its policy development.

Samenvatting

Dit proefschrift draagt bij aan de behoefte aan een kader voor de evaluatie van de beleidsdoelstelling van het realiseren van circulaire steden. Door een brug te slaan tussen de concepten van circulaire steden, beleidscoherentie en beleidsevaluatie, biedt dit proefschrift, met centraal het ontwikkelde *circular city policy coherence framework,* een hulpmiddel voor ex-ante beleidsevaluatie.

Het concept van een circulaire stad is geïnspireerd op biologische metabolische systemen en heeft als doel de materiaal- en energiestromen te sluiten, te versmallen en te vertragen. In de meeste Europese stedelijke beleidsmaatregelen is

De gebouwde omgeving opgenomen als een van de belangrijkste aandachtsgebieden omdat het een grote verbruiker en vervuiler van materialen en energie is, vooral door bouw en sloop. Maatregelen tot het realiseren van een circulair gebouwde omgeving omvatten het doel primaire grondstoffen te vervangen door ten minste secundaire grondstoffen, het aanpassen van gebouwontwerpen zodat ze makkelijker circulair kunnen herbruikt worden, het standaardiseren van bouw en sloop, en het stimuleren van circulaire waardeketens.

Er zijn echter twee problemen die de evaluatie van het beleid voor een circulair gebouwde omgeving in steden bemoeilijken. Enerzijds is er de kwestie van het proces. De meeste beleidsmaatregelen voor circulaire steden zijn minder dan tien jaar van kracht. Gezien de omvang van de stedelijk gebouwde omgeving is per definitie elk beleid langdurig, waardoor vandaag evaluatie van resultaten nog niet mogelijk is. Anderzijds is er het inhoudelijke probleem. Er is namelijk geen duidelijke en algemeen aanvaarde conceptualisatie van een circulaire stad. Dit belemmert de ontwikkeling en gebruik van beleids- en beleidsevaluatiekaders. Daarom is het doel van dit proefschrift om te onderzoeken in hoeverre circulair beleid voor de gebouwde omgeving bijdraagt aan de beleidsambities die steden formuleren. Dit leidt tot de hoofdonderzoeksvraag:

In hoeverre draagt circulair beleid voor de gebouwde omgeving bij aan beleidsambities zoals geformuleerd door steden?

Om deze onderzoeksvraag te beantwoorden, is het doctoraat opgebouwd uit vijf individuele, maar gerelateerde academische studies, namelijk één boekhoofdstuk en vier artikelen.

De eerste studie verkent de conceptualisering van circulaire steden in de academische literatuur. Het introduceert het concept van de circulaire economie en de toepassing van circulariteit op verschillende niveaus van de gebouwde omgeving. Vervolgens wordt een historisch overzicht gegeven van het concept van stedelijk metabolisme als origineel een relatief eng begrip van een circulaire stad, tot de recentere meer holistische begrijpen van een circulaire stad. Bestaande perspectieven en conceptualisaties van de circulaire stad en bibliometrische trends worden gepresenteerd.

De tweede studie onderzoekt de relatie tussen een circulaire gebouwde omgeving en de beleidsinstrumenten voor de implementatie ervan, zoals besproken in de academische literatuur. Dit gebeurt door middel van een systematisch literatuuronderzoek volgens de Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) richtlijnen. Meer dan 140 artikelen zijn geanalyseerd op het gebied van circulair stedelijk ontwikkelingsbeleid (zoals circulariteit, ecologische regeneratie en adaptatie) en beleidsinstrumenten (zoals regelgeving, economie en informatie).

In de derde studie wordt het ex-ante *circular city policy coherence framework* ontwikkeld. Het kader is een combinatie van twee bestaande raamwerken voor de analyse van beleidscoherentie enerzijds, en het analyseren en implementeren van circulaire steden anderzijds. Aan de hand van de campusontwikkeling van de Technische Universiteit Delft, als proxy voor stedelijke ontwikkeling, wordt dit kader getest.

Aan de hand van documentanalyse van bestaande ruimtelijke en circulaire economie plannen, evalueert de vierde studie, gebruik makende van het eerder ontwikkelde ex-ante *circular city policy coherence framework*, de beleidscoherentie van het beleid voor circulair gebouwde omgeving in Greater London. De Greater London Authority (GLA) vormt een interessante case voor het onderzoeken van beleidscoherentie van circulair gebouwd omgevingsbeleid, vanwege haar autoriteit, bestuursstructuur, en schaal.

De vijfde en laatste studie analyseert de resultaten van de ex-ante beleidscoherentie evaluatie van houtbouw in Amsterdam, Nederland. Dit gebeurt in twee stappen. Ten eerste worden beleidsinstrumenten uit verschillende beleidsdocumenten geïdentificeerd en geanalyseerd in termen van hoe ze beogen bij te dragen aan een meer circulaire gebouwde omgeving. Ten tweede wordt een *agent-based model* gebouwd om de toekomstige interacties en uitkomsten van geselecteerde beleidsinstrumenten bij het vergroten van de houtbouw in Amsterdam te simuleren.

Conclusies en implicaties

Dit proefschrift concludeert dat het huidige begrip van een circulaire gebouwde omgeving de stad niet ziet voor de gebouwen. Door een perspectief op circulariteit in de gebouwde omgeving te bevorderen op basis van het concept van circulaire steden, stelt dit proefschrift voor dat het circulaire beleid voor de gebouwde omgeving weliswaar de algehele samenhang heeft verbeterd, met name door middel van bedrijfsgestuurde optimalisaties in bouwpraktijken, maar dat het tekortschiet in het volledig realiseren van een circulaire stad zoals bedoeld in het raamwerk voor de samenhang van het circulaire stadsbeleid. Het circulaire beleid van Londen en Amsterdam is in toenemende mate ontworpen om problemen zoals uitputting van hulpbronnen en afvalproductie te verminderen. Hun beleid gaat echter grotendeels voorbij aan een bredere, meer systemische aanpak, met name wat betreft het beoordelen van de behoefte aan nieuwe gebouwen, het onderhouden en aanpassen van het bestaande gebouwenbestand, en het betrekken van bewoners en gemeenschappen bij de ontwikkeling van een circulaire stad.

De belangrijkste bijdrage van dit proefschrift is het problematiseren van circulair beleid voor de gebouwde omgeving in relatie tot circulaire steden, met een baanbrekende evaluatie van dergelijk beleid in Londen en Amsterdam. Het positioneert de gebouwde omgeving als een sleutelcomponent van circulaire steden en benadrukt de invloed van beleidsbeslissingen op het ontwerp van de gebouwde omgeving. Het werk omvat het eerste systematische literatuuronderzoek naar beleidsinstrumenten voor circulaire gebouwde omgevingen, waarbij een technocratische trend en een focus op kringloopmaatregelen wordt vastgesteld. Het presenteert ook een ex ante beleidsevaluatiekader voor circulaire steden, getest in Amsterdam en Londen, dat de beoordeling van de beleidssamenhang en potentiële effecten mogelijk maakt, aangevuld met een agent-based model om interacties en opkomende eigenschappen tussen beleidsinstrumenten te visualiseren.

Dit evaluatiekader is momenteel het enige (voor zover de auteur weet op het moment van schrijven) dat niet alleen zowel proces- als inhoudsaspecten integreert binnen het beleid voor circulaire steden, maar ook de analyse van beleidsafstemming en synergiën tussen verschillende stedelijke beleidsterreinen mogelijk maakt.

Beleidsmakers zouden dit kader kunnen gebruiken om ambitieuzere en goed afgeronde beleidsmaatregelen te ontwerpen die alle drie de circulariteitsacties omvatten. De beleidscoherentiefactoren zouden de nodige rechtvaardiging bieden om bestaande beleidsdoelstellingen en -instrumenten te verfijnen of om nieuwe voor te stellen voor toekomstige implementatie, en ook om te ontdekken waar of hoe een meer systemisch perspectief van een circulaire stad de beleidsontwikkeling kan verbeteren.

Resumen

Esta tesis pretende contribuir a la urgente necesidad de un marco de evaluación de políticas de ciudades circulares en las ciudades europeas. Al unir los conceptos de ciudades circulares, coherencia política y evaluación política, esta tesis proporciona una herramienta de evaluación política ex ante, a saber, el marco de coherencia política de la ciudad circular.

El concepto de ciudad circular se inspira en los sistemas metabólicos biológicos y tiene como objetivo aplicar los principios de la economía circular en diversos aspectos del funcionamiento urbano, es decir, minimizar el consumo de recursos primarios y energía, reduciendo así los impactos ambientales, como los residuos y las emisiones. Este planteamiento implica redefinir los procesos urbanos para cerrar, estrechar y ralentizar los flujos de materiales y energía.

El entorno construido se incluye como área de intervención en la mayoría de las políticas europeas de ciudad circular por ser un importante consumidor de recursos y contaminador a través de la construcción y la demolición. En general, estas políticas promueven un entorno construido circular sustituyendo las materias primas primarias por otras secundarias como mínimo, normalizando las prácticas circulares en el diseño, la construcción y la deconstrucción, creando mercados para los recursos secundarios y compartiendo conocimientos para integrar las prácticas circulares en las cadenas de valor de la construcción.

Sin embargo, hay dos cuestiones que dificultan la evaluación de las políticas de ciudades circulares, y las específicas del entorno construido. Por un lado, está la cuestión del proceso: la mayoría de las políticas de ciudades circulares llevan menos de una década en vigor, y la escala del entorno construido hace que cualquier política destinada a cambiarlo sea a largo plazo, lo que hace que la evaluación ex post sea poco práctica hoy en día. Por otro lado, está la cuestión del contenido: la falta de conceptualizaciones claras y de uso común de las ciudades circulares obstaculiza los marcos (de evaluación) de las políticas. Por lo tanto, el objetivo de esta disertación es explorar en qué medida las políticas de entorno construido circular contribuyen a las ambiciones políticas formuladas por las ciudades. Esto nos lleva a la pregunta principal de la investigación:

¿En qué medida contribuyen las políticas circulares del entorno construido a las ambiciones políticas formuladas por las ciudades?

Para responder a esta pregunta de investigación, la tesis se estructura en cinco estudios académicos independientes pero relacionados.

El primer estudio explora la reciente conceptualización de las ciudades circulares que se encuentra en la literatura académica. Introduce el concepto de economía circular y la aplicación de la circularidad a diferentes niveles del entorno construido. A continuación, ofrece una narración histórica desde el estudio del metabolismo urbano como lente analítica dominante hasta la comprensión más reciente de una ciudad circular. Se presentan las perspectivas y conceptualizaciones existentes de la ciudad circular, así como las tendencias bibliométricas actuales.

El segundo estudio presenta la relación entre un entorno construido circular y los instrumentos políticos para su aplicación tal y como se debaten en la literatura académica. Esto se hace a través de una revisión sistemática de la literatura siguiendo las directrices de los Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Analiza más de 140 artículos en términos de políticas de desarrollo urbano circular (es decir, circularidad, regeneración ecológica y adaptación) e instrumentos políticos (es decir, normativos, económicos e informativos).

El tercer estudio propone el marco de coherencia política de la ciudad circular ex ante. El marco, resultante de la combinación de dos marcos existentes para el análisis de la coherencia política y el desarrollo de ciudades circulares, se pone a prueba utilizando el estudio de caso del desarrollo del campus de la Universidad Tecnológica de Delft como proxy de desarrollo urbano.

Basándose en el análisis documental de las políticas de desarrollo espacial y economía circular, el cuarto estudio utiliza el marco de coherencia política de ciudad circular ex ante para evaluar la coherencia política -o (des)alineación y sinergias potenciales- de las políticas de entorno construido circular en el Gran Londres. La Autoridad del Gran Londres (GLA) presenta un caso interesante para examinar la coherencia política de las políticas del entorno construido circular debido a su autoridad, estructura de gobernanza, escala y la notable laguna en la investigación sobre gobernanza que no se ha explorado plenamente.

El quinto y último estudio examina una evaluación política ex ante de la construcción en madera en Ámsterdam (Países Bajos), dada su política de ciudad circular de una década de duración y sus recientes ambiciones de construcción masiva en madera. Esto se hace en dos pasos. En primer lugar, se identificaron los instrumentos políticos de diferentes documentos políticos de Ámsterdam y se analizaron en términos de cómo pretenden contribuir a un entorno construido más circular. En segundo lugar, se construyó un modelo basado en agentes como herramienta para que los responsables políticos simulen las interacciones emergentes y los resultados de los instrumentos políticos seleccionados en el aumento de la construcción con madera en Ámsterdam.

Conclusiones e implicaciones

Esta disertación concluye que la comprensión actual de un entorno construido circular no ve la ciudad por los edificios. Al avanzar en una perspectiva sobre la circularidad en el entorno construido basada en el concepto de ciudades circulares, esta disertación propone que, aunque las políticas de entorno construido circular han mejorado su coherencia general, en particular a través de optimizaciones impulsadas por las empresas en las prácticas de construcción, se quedan cortas a la hora de materializar plenamente una ciudad circular tal y como la concibe el marco de coherencia política de la ciudad circular. Las políticas de entorno construido circular de Londres y Ámsterdam están cada vez más diseñadas para mitigar problemas como el agotamiento de los recursos y la generación de residuos. Sin embargo, sus políticas pasan por alto en gran medida un enfoque más amplio y sistémico, sobre todo en lo que respecta a la evaluación de la necesidad de nuevos edificios, el mantenimiento y la adaptación del parque inmobiliario existente y la implicación de los residentes y las comunidades en el desarrollo de una ciudad circular.

La principal contribución de esta disertación es problematizar las políticas de entorno construido circular en relación con las ciudades circulares, con una evaluación pionera de dichas políticas en Londres y Ámsterdam. Sitúa el entorno construido como un componente clave de las ciudades circulares, destacando la influencia de las decisiones políticas en el diseño del entorno construido. El trabajo incluye la primera revisión bibliográfica sistemática de instrumentos políticos para entornos construidos circulares, identificando una tendencia tecnocrática y un enfoque en medidas de bucle. También presenta un marco de evaluación política ex ante para ciudades circulares, probado en Ámsterdam y Londres, que permite evaluar la coherencia política y los impactos potenciales, complementado con un modelo basado en agentes para visualizar las interacciones y las propiedades emergentes entre los instrumentos políticos.

Este marco de evaluación es actualmente el único (por lo que el autor sabe en el momento de escribir estas líneas) que no sólo integra tanto los aspectos de proceso como de contenido en las políticas de ciudades circulares, sino que también permite analizar la alineación de las políticas y las sinergias entre los distintos ámbitos de la política urbana.

Los hacedores de políticas públicas podrían utilizar este marco para diseñar políticas más ambiciosas y completas que incluyan las tres acciones de circularidad. Los factores de coherencia política proporcionarían la justificación necesaria para perfeccionar los objetivos e instrumentos políticos existentes o proponer otros nuevos para su futura aplicación, así como para detectar dónde o cómo una perspectiva más sistémica de una ciudad circular puede mejorar el desarrollo de sus políticas.

1 Introduction

1.1 Circular city policies

In dozens of European cities, policymakers have the ambition to develop more circular cities. Circular cities are a policy goal of the European Union, which aims to help tackle the triple planetary crisis of climate change, biodiversity loss, and pollution (EEA, 2023). The over-consumption and ever-decreasing availability of raw materials and the prevailing unsustainable management of resources jeopardise the sustainable development of the European Union and contribute significantly to the triple planetary crisis. In order to decouple economic growth from resource use, the European Union has been promoting circular cities over the last fifteen years through a series of communications, policies, regulations and economic instruments (e.g. grants, subsidies, taxes) (European Commission, 2020a). Circular city policies normally focus on different areas of urban functioning, such as the built environment, food, transport, housing, manufacturing, plastics, and textiles.

Circular cities are cities that apply the principles of the circular economy to reduce the consumption and use of resources and minimise the generation of waste (Fusco Girard & Nocca, 2019; Paiho et al., 2020). The circular economy envisions an economic system in which waste is reintegrated into the economy as a secondary raw material through various strategies (e.g. recovery, recycling, reuse, reduction, refusal). The circular economy promises to 'close the loop' on the use of materials (EEA, 2023).

The built environment is included in most European circular city policies as an area of intervention due to its profile as a major resource consumer and polluter through construction and demolition. A circular built environment can be conceptualised as the buildings and infrastructure where people and other life forms live and work that is designed, built and managed according to circular economy principles. In a circular built environment, according to the European policies, the focus, lies in applying circular economy principles to keep building assets, components and materials in use as long as possible (EIB, 2024). The construction sector is the most

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included one among circular city and region initiatives in Europe (e.g. Amsterdam, Barcelona, Flanders, Paris, London, Valladolid, Porto, Nantes and North Karelia) (OECD, 2023). In these policies, a circular built environment is generally promoted by replacing primary raw materials with at least secondary ones, standardising circular practices in design, construction and deconstruction, creating markets for secondary resources and sharing knowledge to integrate circular practices into construction value chains (cf. EIB, 2024).

Policy makers in cities are challenged by the lack of evaluate frameworks for circular city policies. According to the OECD (2020)'s *The Circular Economy in Cities and Regions Synthesis Report*, only a few evaluative frameworks exist for circular economy policies. They share common obstacles and challenges such as the lack of an agreed definition on the circular economy, lack of harmonised sets of indicators, incomplete information, a prevailing focus on waste but little on closing material loops, and the fact that most available indicators are data-driven rather than objective-driven. Evaluative frameworks enable the assessment of performance and progress of policy, in order to know what works, what does not and suggest changes in policies. For instance, the evaluation of European circular economy policies has shown that most resources allocated from the EU to support the transition towards the circular economy in national and sub-national government are highly ineffective and inefficient (European Court of Auditors, 2023). The European Court of Auditors (2023)'s special report *Circular Economy – Slow transition by member states despite EU action* points out that between 2014-2020 more than EUR 10 billion in funding for the circular economy transition meant for investment in circular design of products and of production processes was largely used for waste management. The OECD (2024c) points out that currently there is no harmonised evaluation framework for the circular economy and, although different (sub)national governments have implemented monitoring and evaluation frameworks, those framework hardly apply to cities and regions due to the difficulty of using national indicators at the local scale. Without proper evaluation, circular city policies run the risk to be ineffective in making cities more circular.

This dissertation explores the evaluation of circular city policies within the context of the built environment as a way of understanding their potential impacts and providing policy makers with opportunities for policy improvement. It does so by proposing a framework for ex ante policy evaluation that combines process and content dimensions of different built environment policy areas to ensure more coherent policy outcomes. The framework has been applied to two European cities and improved, namely London (UK) and Amsterdam (the Netherlands).

The following section (1.2) introduces the conceptual framework of the dissertation. Section 1.3 defines the research problem and presents the aim of the research, the knowledge gap, the research objectives and the research questions. The research methods are explained in section 1.4. The chapter concludes with the expected contribution of the research from a societal and academic perspective (section 1.4) and the outline of the dissertation (section 1.5).

1.2 The challenge of circular city policy evaluation

Evaluating circular city policy has proved challenging. Firstly, there is the issue of conceptualising circular cities. Among European policymakers and scholars there is no widely agreed concept for the circular economy and subsequently for circular cities (Kirchherr et al., 2017; Kirchherr et al., 2023; Korhonen et al., 2018b; OECD, 2020). Secondly, most European circular city policies have been established in the past seven years (2017-2024) (cf. European Union, 2023) and as a nascent policy objective, and due to the limited set of data, indicators, conceptual and evaluative frameworks currently available for the circular cities, it is difficult to comprehensively evaluate these policies (OECD, 2020). A circular city aims to sustain systemic sustainability transformations in urban areas (Williams, 2021a), emphasising the need to align multiple urban policies and instruments over time and place; policies that to date were predominantly siloed (OECD, 2024a, 2024b). For example in the built environment, which, given its magnitude and slow rate of buildings replacing old building stock or expanding the total stock (1% a year) in Europe (Artola et al., 2016) creates difficulties for evaluation. These characteristics pose a challenge to conventional (ex post) policy evaluation that is carried out after a policy is implemented and shows evidence of desired changes taking place (Howlett et al., 2020). For instance, it might take a long time to have estimations of. a growing rate of circular renovation of buildings or of buildings designed under the principles of eco-design[1]. Finally, the combination of the lack

1 According to the European Environmental Agency, eco-design means the “e integration of environmental sustainability considerations into the characteristics of a product and the processes taking place throughout the product’s value chain” (European Union, 2024, p. 26).

of a common conceptualisation of circular cities and the difficulties stemming from the impracticality of ex post policy evaluation leads to an emerging issue: a possible lack of coherence or alignment between policy objectives, instruments and implementation measures, which ultimately affects the effectiveness of policies (May et al., 2006) and the development of more circular cities. The challenge addressed in this dissertation lies in the combination of these three concepts, namely (1) the substantive understanding of the circular built environment as focal area within the circular city concept and of policies that support such circular built environment development, (2) the process-oriented understanding of policy development and evaluation, and (3) the combined substantive and processual understanding of policy objectives, instruments and implementation as indication of policy coherence, which contributes to policy effectiveness.

1.2.1 Circular cities

The concept of circular cities has its roots in the field of industrial ecology and the study of urban metabolism in the mid-20th century. According to Jelinski et al. (1992) Industrial ecology is a field devoted to the systemic relationships of industries in terms of the material an energy flows. It explores the potential of using industrial secondary raw materials in productive processes or the idea that one industry’s waste can be other industry’s raw material input (e.g. waste heat from a company used as heating source for another). Later on, urban metabolism, or the idea of the city as a metabolic unit and system that intakes energy and materials, use them to function, and excretes waste and emissions, was developed (Ferrao & Fernandez, 2013). The work of Wolman (1965) and Duvigneaud (1975) on the study of the metabolism of cities cemented the analysis of material and energy flows in urban areas. More than 100 cities have conducted urban metabolism analyses to quantify and assess their building stocks, carbon footprint, regional resource exchange, and environmental impact among other purposes (Metabolism of Cities, 2024). More recently, urban metabolism has been criticised given its prevailing technocratic approach and as it tends to overlook questions of power and human agency in relation to material and energy flows in and for the urban space, as if resource flows were naturally occurring (Kaika, 2005; Wachsmuth, 2012). The application of circular economy principles in city development has also been critiqued for not adequately addressing more fundamental aspects of urban functioning (Williams, 2019a).

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A circular city and a circular economy are different concepts. A circular city is a spatially bounded, locally managed complex adaptive system that focuses on delivery systems such as infrastructure and services (Williams, 2019a, 2021a). In contrast, a circular economy focuses on improving the efficiency of production systems and minimising environmental impacts (Van den Berghe & Verhagen, 2021; Van den Berghe & Vos, 2019). According to the Ellen MacArthur Foundation, the circular economy achieves efficiency and reduces environmental impact through a system where materials are continually reused, preventing waste and regenerating nature through processes like maintenance, reuse, refurbishment, remanufacturing, recycling, and composting (Ellen MacArthur Foundation, 2016). Often, the implicit primary goal of a circular economy is the sustainable accumulation of capital and wealth (Molotch, 1976; Savini, 2023; Williams, 2020, 2021a). The lack of a clear definition of a circular city makes it difficult to design and implement circular city policies. For example, research in Melbourne, Australia, and Malmö, Sweden, suggests that misinterpretation of the circular economy concept can undermine the effectiveness of circular policies in urban strategic planning (cf. Bolger & Doyon, 2019). In Amsterdam, Calisto Friant et al. (2023) point out that circular city policies can be categorized as driven by economic development and lacking policy actions in relation to the built environment, spatial planning, and the inclusion of nature based solutions, a situation that Calisto Friant et al. (2023) claim could affect the effectiveness of such policies. Ultimately, the way in which policy objectives, such as that of circular cities, are formulated has a significant impact on the choice and coherence of the instruments and policies used to address them (Howlett et al., 2020).

Circular built environment policies in particular have predominantly been shaped by a construction management perspective (Ness, 2022). Given that the construction sector is a significant contributor to pollution and resource consumption (Nußholz et al., 2023), policymakers have focused their circularity initiatives on construction supply chains (cf. EIB, 2024). However, Williams (2019d, 2021a) has criticised this flow-centred approach, arguing that it neglects to consider the built environment as a component of a complex adaptive system: the city. Simply making flows circular through the reuse of resources and the minimisation of waste or "*getting the flows right*" within urban areas is insufficient to achieve a more circular urban metabolism (Ness, 2022; Wachsmuth, 2012). The built environment possesses artefactual complexity, as each built element is context dependent and evolves through the actions of individuals, thereby shaping the city (Marshall, 2012).

1.2.2 Policy evaluation

Public policy can be described as a series of coordinated decisions made by political actors to define objectives and the methods to achieve them within the limits of their authority (Jenkins, 1978). The study and development of public policy often follows a *policy cycle* or process, which typically comprises five stages: 1) agenda setting, where issues are brought to the attention of government; 2) policy formulation, which involves the creation of policy options within government; 3) decision making, the stage where government chooses a specific course of action or opts for inaction; 4) policy implementation, which is the execution of these policies; and 5) evaluation, which focuses on monitoring and assessing outcomes, which may lead to changes in the identified problems and proposed solutions (cf. Howlett et al., 2020; Jann & Wegrich, 2017).

Policy evaluation is the process of retrospectively (ex post) assessing the outputs and outcomes of a policy after it has been implemented to determine whether the policy objectives have been met. Policy evaluation typically involves analysing the policy processes through inputs and outputs, providing valuable information for the implementation phase (Wollmann, 2009), or analysing the impacts based on the policy's effects (Howlett et al., 2020).

Alongside the development of computer simulations used for policy evaluation, another type of public policy evaluation has emerged[2]: ex ante evaluation (Boero et al., 2015). Unlike ex post evaluation, which takes place after a policy has been implemented, ex ante evaluation is conducted before a policy is implemented. Its purpose is to assist in policy formulation or in the selection and design of policy objectives and instruments, and potentially to predict and assess the effects and consequences of a policy in advance (Howlett et al., 2020; Wollmann, 2009). While ex ante and ex post approaches are increasingly used for policy evaluation, it has so far proved difficult to link both approaches in institutionalised frameworks for policy evaluation (Adelle & Weiland, 2012) and remains under-theorised (Mergaert & Minto, 2015). Boero (2015) identifies two issues in policy formulation that make ex-ante evaluation scientifically valuable, apart from its practical benefits in testing the robustness of public policies. These issues are: 1) the rapid enthusiasm around a policy option and 2) the emergence of new issues where knowledge is still

2 Simulations have been used to support policy and decision making for over five decades. A notable example is the computer simulations carried out for the report The Limits to Growth by Meadows et al. (1972a), which were used to simulate the consequences of the interaction between the Earth and human systems.

developing, such as the circular economy (cf. Kirchherr et al., 2023; Korhonen et al., 2018b). The latter is of special interest for this dissertation. Ex-ante evaluation is valuable for it improves policy design by challenging policy objectives and testing underlying assumptions to ensure that they are feasible and consistent. In addition, where empirical evidence is lacking, ex-ante evaluation can be valuable for conducting what-if analyses, using available data while exploring hypotheses about the unknown (Boero et al., 2015).

1.2.3 Policy coherence

The concept of policy coherence involves the consistency of policy design and implementation and it has been used for ex ante policy evaluation (Righettini & Lizzi, 2022). Ideally, coherence exists within policy-making as different policies should be aligned towards common objectives (May et al., 2006). Policy coherence is defined as *"an attribute of policy that systematically reduces conflicts and promotes synergies between and within different policy areas to achieve the outcomes associated with jointly agreed policy objective"*" (Nilsson et al., 2012, p. 396). Increased coherence is expected to lead to greater policy stability and effectiveness (May et al., 2006). The study of policy coherence gained prominence in the 2000s (Carbone, 2008; May et al., 2006; Picciotto, 2005), but it wasn't until 2015 that there was a sustained increase in publications on the topic. These publications mainly fall into two categories: *governance coherence*, which refers to multi-level policy-making processes, and *policy-specific coherence*, which focuses on the alignment of objectives and instruments within a specific policy area (Righettini & Lizzi, 2022). According to Nilsson et al. (2012), coherence involves the relationships between policies, either within a single policy domain (internal coherence) or across different policy domains (external coherence). Interactions can also be classified as vertical, referring to relationships at the same level of governance, or horizontal, referring to relationships across different spatial scales of governance. For coherence analysis, policy domains are divided into three analytical units, namely objectives, instruments and implementation practices. Despite the establishment of different research directions and methodological frameworks for policy coherence analysis (cf. Righettini & Lizzi, 2022), the field typically faces two challenges: 1) defining system boundaries to identify policies that should be aligned, and 2) the difficulty of directly measuring policy coherence (May et al., 2006, p. 382).

Formulating effective circular built environment policies requires multi-level decision-making by different stakeholders, often with conflicting interests, operating in different markets (van Bueren & Priemus, 2002) and within different physical and administrative jurisdictions (van Bueren & De Jong, 2007a). The wicked[3] nature of policy domains such as a circular built environment (for which aims are set to transcend commonly understood domain boundaries), in combination with the issues regarding circular economy and circular city conceptualisation and policy making can result in incoherences that in turn can hinder the implementation [and / or the effectiveness?] of circular built environment? policies. As discussed above, there is a prevailing lack of common conceptualisations of the circular economy and circular cities, which makes it difficult to unequivocally formulate policy objectives and instruments, and to have a clear idea of what should be evaluated in circular city and built environment policies. The short lifespan of circular city policies and the long-term goal of circular built environment policies (given its magnitude and slow rate of replacement) also makes it difficult to evaluate policies after they have been implemented, compromising the identification of what works, what does not and how it could be improved in future policy cycles. This dissertation explores the coherence of circular built environment policies as an approach to policy evaluation: regardless of how far circular built environment policies have progressed in their implementation, coherence analysis draws on what is currently available, such as policy objectives, instruments and planned implementation measures across different urban policies. Policy coherence is desirable in circular city transitions given the urban sustainability transformations these policies intend to trigger and the different policy domains that could be involved, such as transportation, food, water, and housing (OECD, 2020, 2023).

3 Wicked problems in public policy can be described as policy issues that are complex, have no definitive formulation, are not true-or-false but good-or-bad problems, have no immediate and no ultimate test of a solutions, are essentially unique, and the choice for their explanation determines the nature of the problem's solution, among other characteristics (Rittel & Webber, 1973).

1.3 Problem formulation

1.3.1 Research problem

Current evaluation frameworks for the circular economy cannot be used for cities as they rely on national data and indicators difficult to translate into subnational indicators (OECD, 2024c). These available frameworks are partial, as they mainly focus on policy-making processes, overlooking the content of circular city policies (which is related to the lack of commonly agreed conceptualisations of circular cities), and lack attention to the need for coherence between urban policies to trigger the systemic urban transformation that circular city policies are intended to trigger (Williams, 2021a).

1.3.2 Research gap

In recent years, scholars have raised concerns about the governance of circular built environment. More specifically, some scholars have pointed out the lack of policy frameworks and policy evaluation in support of design and evaluation of circular built environment policies (Munaro et al., 2020; Ness & Xing, 2017a; Pomponi & Moncaster, 2017; Yu et al., 2022). Historically, policy evaluation has prevailingly focused on issues of policy *process* and *effects* (Howlett et al., 2020; Wollmann, 2009) by means of ex post evaluation (Adelle & Weiland, 2012). Historically, a policy has been deemed effective (and positively evaluated) if it achieves the desired policy objective (Howlett et al., 2020). To determine policy objectives, stakeholders' claims, concerns and issues serve as basis for determining what policy choices are made and what is to be evaluated (Guba & Lincoln, 1989) However, when looking into a developing research field such as the circular economy, where concepts have not been entirely explored and understood (Korhonen et al., 2018b), how can policymakers and researchers believably argue that their policy choices are indeed circular and effective? (Remy et al., 2017).

As pointed out in different OECD reports on the circular economy in Europan cities, the lack of evaluation frameworks for circular cities, and the built environment in particular lie in the question of policy *content* and alignment with other existing urban agendas (e.g. urban development, food, water, transport, housing) (OECD, 2020, 2023, 2024b). The recently proposed policymaking framework for the circular built environment by Yu et al. (2022) includes evaluation by means of Lifecycle assessment (LCA) and Lifecycle Costing (LCC), the quantification of construction and demolition waste and the development of circular economy performance indicators. While this framework combines issues of process and content to ensure the effectiveness of policymaking processes in the built environment, it is restricted to the domain of construction by looking into supply chains and therefore does not link the circular economy to other urban agendas.

This dissertation intends to fill the gap of circular built environment policy evaluation by exploring coherence as a means of ex ante evaluation. This dissertation will investigate the assumption that an effective circular city and built environment policy is one that bridges policy process and content coherently (i.e. aligning policy objectives, instruments and implementation measures and creating synergies among them (May et al., 2006; Nilsson et al., 2012)). By bridging process and content in the evaluation of circular built environment policy, this dissertation seeks to contribute to the emergent research field of circular built environment and more practically to policymakers in looking for evaluative frameworks and ways to align their circular built environment policies with other existing urban agendas.

1.3.3 Research aim and objectives

This research aims to explore *to what extent* circular built environment policies contribute to policy ambitions as formulated by cities. This is done by assessing coherence as means of ex ante evaluation of circular built environment policies. The objectives of this research are:

- To conceptualise a circular built environment.
- To understand the relationship between a circular built environment and the policy instruments needed to bring about a circular built environment, as in academic literature.
- To explore the potential of combining existing frameworks for circular city development and policy coherence to inform policy makers on improving circular built environment policies.
- To evaluate the coherence of circular built environment policies.
- To demonstrate how policy coherence can help to enhance circular built environment policy.

1.3.4 Research questions

Main Research Question

- **To what extent do circular built environment policies contribute to policy ambitions as formulated by cities?**

Sub-Research Questions

- What is a circular built environment?
- What is the current understanding of the relationship between a circular built environment and policy instruments needed to bring about a circular built environment?
- What is the potential of combining existing frameworks for circular city development and policy coherence in informing policymaking?
- How coherent are circular built environment policies?
- How can policy coherence help to enhance circular built environment?

1.4 Research approach

1.4.1 Research paradigm

This research follows a pragmatist research paradigm. Pragmatism emerged as a response to the duality between the (post-)positivist and constructivist paradigms in science, with the former claiming that the world exists independently of people's ideas about it, and the latter claiming that the world is created by our ideas about it (Biesta, 2004; Morgan, 2014). Pragmatism builds on the work of Dewey in the late 19th century, particularly in its systematic approach to inquiry (a process by which beliefs are problematised, examined and resolved through action). The pragmatist paradigm has gained considerable attention in the social sciences, particularly in mixed methods projects, as it supports the use of any method that serves the research purpose, in contrast to the restrictive dualism of (post-) positivism and constructivism, which favour qualitative and quantitative methods respectively (Morgan, 2014).

The inquiry approach distinguishes five steps (Dewey, 2008) and can be linked to this dissertation as follows: 1) Identifying a situation as problematic (e.g. evaluating circular city policy); 2) Assessing the implications of defining the problem in different ways (e.g. circular economy versus circular cities); 3) Formulating a possible response to the problem (e.g. proposing a framework for evaluation); 4) Analysing potential actions based on expected outcomes (e.g. applying the framework to selected case studies); and, 5) Implementing actions that are considered effective in addressing the problem (e.g. applying the framework to selected case studies).

Given the exploratory nature of this dissertation, a mixed methods approach was chosen. This is because mixed methods research, among other things, responds to the need to develop, implement and evaluate a phenomenon by collecting both qualitative and quantitative data in exploratory research where the questions are not necessarily predetermined given the emerging essence of the research problem at hand (Creswell & Clark, 2017). A mixed methods approach can provide a better understanding of quantitative results and increases the generalisability of qualitative findings (Dos Santos Vieira Brysch, 2023), as well as provide a broader perspective on research questions when quantitative or qualitative methods alone are not sufficient (Almeida, 2018).

This thesis adopts a case study approach. This approach is useful in research projects aimed at theory building (Eckstein, 2009) as well as describing, understanding, predicting and/or controlling individual processes, people, organisations and cultures (Woodside & Wilson, 2003), among others, because it looks in depth at a single unit of analysis (circular built environment policies for this dissertation) for the purpose of understanding a larger class of (similar) units (Gerring, 2004). It uses three case studies, the first for the development of the ex-ante policy evaluation framework using an urban development proxy, namely the campus development at Delft University of Technology, and two applied case studies for the evaluation of circular built environment policies in London (UK) and Amsterdam (The Netherlands). The case studies are also used to further validate and test the evaluation framework.

1.4.2 Scope and case study selection

The scope of this research is European cities. As argued by Williams (2021a), circular cities are a European phenomenon that has been widely supported by the European Union through different policies and instruments (EEA, 2023; European Commission, 2020a, 2020b; European Court of Auditors, 2023). European cities have been pioneers in developing circular built environment policies, which are distinctive from waste management frameworks (Cramer, 2022; Yu et al., 2022). It is worth noting that in this dissertation circular cities are approached from the perspective of the built environment policy; it is a way to practically access the study of circular city policy evaluation from one of its constitutive elements and by no means used interchangeably as concepts.

The selection of cases follows an information-oriented approach, which aims to maximise the usefulness of small samples and individual cases, selected on the basis of their expected information content (Flyvbjerg, 2006). Information-oriented selection is particularly useful for exploratory research and theory building, as it provides an entry point for investigation when much data has not yet been produced (Gerring, 2004; Woodside & Wilson, 2003). Cases were selected according to the following criteria: 1) cities must have circular economy policies that include the built environment as an area of intervention; 2) circular built environment policies must be distinct from traditional waste management frameworks; 3) circular built environment policies must insights into the successive crystallisation of policy objectives into instruments and implementation measures; 4) policy documents should be publicly available and accessible at the time of research to avoid delays due to administrative access requests and to improve the replicability of research findings.

1.4.3 Research design and methods

Drawing on the emerging and growing literature on circular built environment research, this dissertation seeks to explore policy evaluation, thereby contributing to the body of knowledge on circularity in urban areas. It does not aim to provide an exhaustive account of circular built environment policies, nor does it aim to provide well-formed solutions to the problems that may arise. As this is an article-based dissertation, a detailed explanation of the methods and materials used for each paper can be found in each chapter. Table 1.1 links the different aims of this dissertation with the methods used and a brief explanation for their inclusion.

TABLE 1.1 Methods in relation to research objectives.

Objective I	**To conceptualize circular built environment.**
Methods	Literature Review and Bibliometric Analysis.
Explanation	Recently, a variety of circular city concepts have been proposed by scholars, but the relationship between a circular city and its built environment has not been substantially addressed. A literature review and bibliometric analysis for circular cities helps to frame discussions on the circular city concept. The review links the circular city concept to its application in the built environment.
Objective II	**To understand the relation between a circular built environment and the policy instruments to bring it about, as discussed in academic literature.**
Methods	Systematic Literature Review.
Explanation	While the literature on circular built environment is growing, the role of policy instruments proposed for its implementation remains uncovered. Therefore, an exhaustive systematic literature review provides the state of the art of policy instruments for a circular built environment in relation to circular city development.
Objective III	**To develop and test a framework for ex ante policy coherence analysis of policies contributing to a circular built environment.**
Methods	Semi-structure Interviews and Policy Document Analysis.
Explanation	Given the early stage of development of most circular built environment policies, a framework for ex-ante policy evaluation (Circular City Policy Coherence) is proposed and tested in the case of campus development at Delft University of Technology in the Netherlands. The analysis is enabled by existing policy objectives, instruments and implementation practices contained in national, provincial, local and internal policy documents, as well as through semi-structured interviews with sustainability professionals working for campus development and operations.
Objective IV	**To evaluate the coherence of circular built environment policy in applied cases.**
Methods	Semi-structure Interviews, Policy Document Analysis
Explanation	A more thorough application of the framework developed and tested for the previous objective results from the study of circular built environment policy in Greater London. In this case, the coherence between circular economy policy and spatial development policy is analysed with the Circular City Policy Coherence framework. Exploratory semi-structured interviews are conducted to identify policy documents. Policy documents analysis is used to assess the overall coherence of circular built environment policy in Greater London.
Objective V	**To demonstrate how circular city policy coherence can help to enhance circular built environment policy.**
Methods	Semi-structure Interviews, Policy Document Analysis, and Agent-Based Modelling
Explanation	To demonstrate the usefulness of the Circular City Policy Coherence framework as well as to further explore ways of using ex ante evaluation in policy formulation for circular cities, the case of timber construction policy in Amsterdam is analysed. Agent-Based Modelling is used for ex ante evaluation of existing and proposed policy instruments to incentivise the use of mass timber in the construction sector.

1.5 Research contribution

1.5.1 Scientific relevance

The scientific relevance of this dissertation lies in the development of an evaluation framework for circular city policies, focusing on those targeting the built environment. As discussed above, the circular economy has typically been studied from a supply chain perspective, seeking to introduce principles such as recycle, reuse and reduce in order to promote more sustainable economic growth and capital accumulation. More recently, scholars have explored the territorialisation of the circular economy in urban areas under the concept of circular cities. Within the field of circular cities and the built environment, research has only recently begun to fill the knowledge gap on governance. This research contributes to filling this gap with exploratory research that develops an evaluation framework for circular city policies that includes process and content dimensions.

This dissertation also contributes to policy evaluation theory by further proposing the analysis of policy coherence as a means of ex-ante policy evaluation (cf. Righettini & Lizzi, 2022). An evaluation framework that takes into account the structured study of policy-making (by looking at the formulation of policy objectives and instruments) and the conceptualisation of circular cities (as an option to the circular economy) allows a focus on the process and content of circular built environment policies, in contrast to prevailing policy evaluation frameworks that focus on the (due) process of policy-making and its outcomes.

1.5.2 Practice and societal relevance

The societal relevance of this dissertation lies in the need of urban policy makers for an evaluation framework for circular city policies. As city governments are encouraged by the European Union to adopt circular city policies through initiatives such as the Circular Cities and Regions Initiative (CCRI) and the European Investment Bank's Circular City Centre (C3), they are also realising that designing and subsequently evaluating these policies is a challenging task in the absence of widely agreed concepts, indicators and frameworks (OECD, 2020). By exploring the ex-ante evaluation of circular city policies, this paper provides a framework that can be used both in the early stages of policy design as a preliminary ‘checklist’ of policy objectives, instruments and circular city actions, and in the late stages of evaluation to assess the outcomes of circular city policies.

The proposed policy evaluation framework may also be of interest to other urban communities, such as universities and research centres interested in circular city governance, civil society organisations interested in the content and progress of circular city policies, and design and construction companies working with circularity interested in evaluating policy frameworks for the interest of their shareholders and the companies themselves (e.g. policy objectives and instrument follow-up).

1.6 Thesis structure

This dissertation follows a study-based structure. Chapters 2, 3, 4, 5 and 6 present five studies, which have been published as a peer-reviewed book chapter (chapter 2) and scientific articles (the remainder). The last chapter provides the overall conclusions and reflections on the research’s key findings and research contribution.

- **Chapter 2** – Circular cities: A conceptualisation
- **Chapter 3** – Policy instruments for a circular built environment: A systematic literature review
- **Chapter 4** – A framework for evaluation circular policy coherence: A case study
- **Chapter 5** – Circular city policy coherence in Greater London
- **Chapter 6** – How ex ante policy evaluation supports circular city development: Amsterdam’s mass timber construction policy

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2 Circular cities

A conceptualization

Adapted from: Bucci Ancapi, F., Van Bueren, E., Van den Berghe, K. (2022). Circular Cities. In: The Palgrave Encyclopedia of Urban and Regional Futures. Palgrave Macmillan, Cham.

Definition

Circular city is a concept inspired by biological metabolic systems that seeks to apply the principles and strategies of the circular economy at the different scales of urban functioning. By doing so, a circular city is meant to reduce the intake of primary resources and energy and resulting environmental impacts, such as waste and emissions. Its functioning is (re)defined by efforts aiming to close, narrow and/or slow material and energy flows. A circular city is a normative concept, implying thus there is an ambition to switch the current – linear – consumption-production system into one that works and develops circularly, in closed loops. It is also normative as it proposes the urban scale as the main spatial level of implementing circularity. As cities in the 21st century deal with their historical ecological impacts, circular cities also embrace ecological regeneration and adaptation measures to maintain their development within the carrying capacity of Earth.

This definition is a compendium of the perspectives contained in this chapter. Thus, although not exhaustively, this definition seeks to provide a common frame of reference for the study of circular cities.

2.1 Introduction

Cities are complex systems of production and consumption. Their ecological impacts have grown significantly in the last decades. Currently, cities consume 60-80% of natural resources globally, while producing around 50% of global waste and 75% of greenhouse gas emissions (UN, 2019). Urban population is expected to increase in the coming decades, reaching 6.5 billion by 2050, the equivalent of two thirds of the future global population (UN, 2017b).

While the attention for the environmental impact of cities and material flows is not something new (cf. Wolman, 1965), arguably, it has recently become more popular within sustainable urban development, along with the increasing popularity of the concept of circular cities (Williams, 2019c). A circular city aims to close material and energy flows that are used by and within its boundaries and thus reducing its overall environmental externalities, such as ecosystem degradation, green-house gas emissions and waste generation. In some cases, a circular city also includes social and economic goals, but in general the focus of circular cities and the circular economy (CE) is on material and energy flows (Korhonen et al., 2018b). Following this, circular cities received a fair amount of critique. The most heard critique is that the knowledge development and implementation of circularity and/or the CE, is too technical and fails to include other dimensions such as the economy, culture, social affairs, politics, governance, design or spatial planning (Korhonen et al., 2018b; Pomponi & Moncaster, 2017; Williams, 2019c).

This chapter explores the concept of circular cities. In the first section, a broader concept of CE is provided. Secondly, the challenge of scale and responsibility in the CE are explained. Thirdly, the chapter continues by tracing the origin of the concept of circular cities. Fourthly, different contemporary definitions of circular cities are covered, as well as their recent increase in publishing. Finally, this chapter ends with an outlook of challenges for circular cities in their implementation.

2.2 The circular economy

The CE gained momentum from 2010 onwards in the western world when the Ellen MacArthur Foundation (EMF) developed the ‘butterfly diagram’ depicting closing loops of biological and technical resources (Ellen MacArthur Foundation, 2016; EMF, 2012). However, one may not forget that it was the Chinese government that first clearly introduced the concept in its 1996 Five Year Plan (Su et al., 2013). In the years following, the CE has been put to the forefront, among others by the UN (2017a), the OECD (2019) and the European Union (EC, 2019) as a focus strategy. In a nutshell, “*the objective of a CE is to reduce the societal production-consumption systems’ linear material and energy throughput flows by applying materials cycles, renewable and cascade-type energy flows to the linear system.*” (Korhonen et al., 2018b, p. 547). Often, the CE is linked to the so-called hierarchical ladder of R-strategies to prevent and to Rethink, Reduce, Reuse, Remanufacture, Recycle, Recover the use of materials (Reike et al., 2018), as it builds upon the waste management hierarchy developed by Lansink, a Dutch Member of Parliament in 1979, and later introduced in the EU legislation with the 2008 Waste Framework Directive. The Directive distinguishes prevention, preparing for reuse, recycling, recovery, and landfill on a preferential scale (EC, 2008). Simply said, the rule of thumb is the higher on the R-ladder, or earlier in the production-consumption system (Korhonen et al., 2018a), the less resources and energy are needed. During the last decades, the focus of waste management has changed. While first the challenge was to avoid landfilling and incineration, the main attention changed to increasing reusing and recycling of primary and secondary materials (Van den Berghe et al., 2020). However, by now it is known that there are not enough secondary materials that can substitute the use of primary materials (PBL, 2021a). To achieve CE-ambitions, it will be pivotal to move up the R-ladder, beyond recycling (PBL, 2019).As the CE finds its ways within urban development, different aspects of a city’s daily operations require adaptation at different scales of urban aggregation – i.e., at the household, neighbourhood, city, or regional level. To illustrate the question of scales, in the next section we examine an elemental aspect of (circular) cities: its built environment.

2.3 Applying circularity at multiple levels of the built environment

Analytically, different layers or levels of spatial scales can be identified in the built environment. These can range from fine-grained scales such as materials and components to more coarse scales such as neighbourhoods, districts, cities, countries, and the global. When circularity is understood as closing material and energy loops while minimizing input and output with minimized impact on the human and natural environment, it can more easily be applied to the lower scales than to the higher ones. Up to the scale of the building level, the concept of closing loops has an inherent logic, pleading for the reuse of materials, building components, and buildings. While circularity can be best understood to the lower scales, the other way around, the circular *economy* can be better understood in line with higher scales, such as nations or the global level. Conceptually, the lower scales deal more with the circularity of products and the design of those, but only to a minor level consider the material and immaterial flows, institutions, and agency, better known as the economy, that enable these to be produced and consumed. From the global level downwards, it is better to imagine what a CE implies, but it becomes more difficult if it is translated to the exact locations where these consumption-production networks take place. Conceptually, they confluence at the area level, city level or regional level. Arguably, this scale is where the circular produced components and built environment come together with the CE consumption and production system. Otherwise said, a circular area/city/region cannot exist without a circular built environment and circular products, and a circular consumption-production system where that area and those assets, people, institutions, and materials are part of (Figure 2.1).

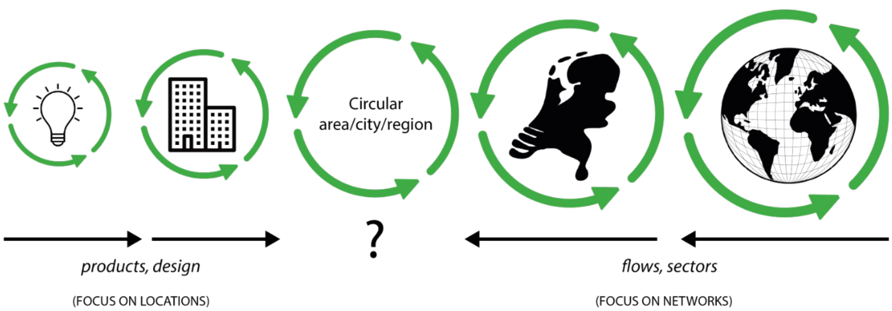

FIG. 2.1 How conceptually circularity (cf. design and locations) and CE (cf. flows and networks) come together at a circular area/city/region. Adapted from Van den Berghe (2021).

This is not really something new. If one imagines how an area (should) function(s), logically one (implicitly) connects how the built environment and exact locations of assets, people, and institutions, interact in networked systems, crossing borders in many different aspects. However, as the next paragraph explains, this reasoning is not at all something that is followed within contemporary CE literature.

2.4 From metabolic to circular cities

To start off with, it is important to underline that a circular city is a normative concept, for it states that a city is a reality, one that consumes and produces materials, which – apparently – to date tends to be mostly linear (take, make, use, waste) and should become circular. The latter is influenced by the increasing attention for environmental issues since the 1970s, and by now as an idea arguably easy to understand. Yet, taking the city as a given is not straightforward. Brenner and Schmid (2014) question the abundant non-critical use of the city as a given object and argue that the city is at highest a statistical artefact that shall always remain a subject of reconsideration and, consequently, a circular city is all but a clear concept. To understand why circular cities are nonetheless so prominent, even though it is not very clear what it is, we first need to understand the epistemological history of a city, and how it confluences with (material) flows, that are normatively expected to be circular instead of linear.

Although always arbitrary, following Wachsmuth (2012), through several stages in time the two conceptualizations – city and (circular) material flows – became intertwined and increasingly the city became seen as both the problem and the solution to environmental problems, the latter thus illustrated by a circular city. Firstly, in the era of industrialization, the idea of an industrially provisioned city started to emerge. Industrial capitalism, the factory system of production, was significantly changing the relation between human and nature, resulting in a society-nature divide (Foster, 2000; Polanyi, 1944; van Driel, 2016). During the industrial revolution, manufacturing concentrated increasingly in and around urban areas. This in turn created a new working class with new political ideas, new organizational forms, and collaborative infrastructures. As such, cities emerged as political, social, and economic bodies as opposite to the non-city, or countryside. The city became seen as the human social optimum, in contrast to the non-human countryside, that was primarily there in support of the city. This idea can be found back within the

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urban studies and sociology works at the late 19th and early 20th century. Ebenezer Howard described the opposition of town and country (Howard, 1989), but foremost the Chicago School established the widespread idea of city versus non-city. Among their words, the city became seen as a self-contained system of people and social relations that grows along with the increase of interactions. Here we encounter a contradiction: How can a self-contained system grow?

By the 1960s and 1970s, best illustrated by the work of the 'Club of Rome' (Meadows et al., 1972b), it became rather clear that the social growth of 'self-contained' systems was impacting the non-city, or nature, in a very negative way. The observed environmental problems caused by human actions triggered researchers to increase their understanding. Here lies the birth of industrial ecology (IE), examining how materials and energy flow through industrial systems of consumption and production, in analogy with ecosystems (Erkman, 1997). Subsequently, IE and the perspective of the city as a system started to intertwine. The city became seen as a system that converts natural resources, also known as urban metabolism. Especially the work of Wolman (1965) was pivotal in conceptualizing the city as a metabolic system. By carefully graphically analysing the metabolism of the city of Brussels, Wolman showed how the city is an open system.

Wolman's understanding of the city also demarcated an epistemological shift: while before the city was primarily seen as an isolated social system, without the inclusion of natural sources, thereafter the city was seen as a system fuelled by natural resources, but without the inclusion of the human (cf. Newell & Cousins, 2015). The city was understood as a sort of machine, without a reference by whom, why and how natural resources are converted. This urban metabolic perspective eventually became normative once it linked to circularity (Stahel, 1982). Figure 2.2 shows the current linear urban metabolism of cities, and how this metabolism could be improved by reducing resource inputs into the urban system (Rogers & Gumuchdjian, 1997). In a circular urban metabolism, resources are used and reused as much as possible once they are in the system, while avoiding degradation of resources as much as possible, and minimizing the output of resources, in the form of waste or emissions. The concentric circles in the figure show the hinterlands from where resources are draw and where resources are collected, remanufactured and up- or down-cycled, adding a geographical perspective to the modelled resource flows.

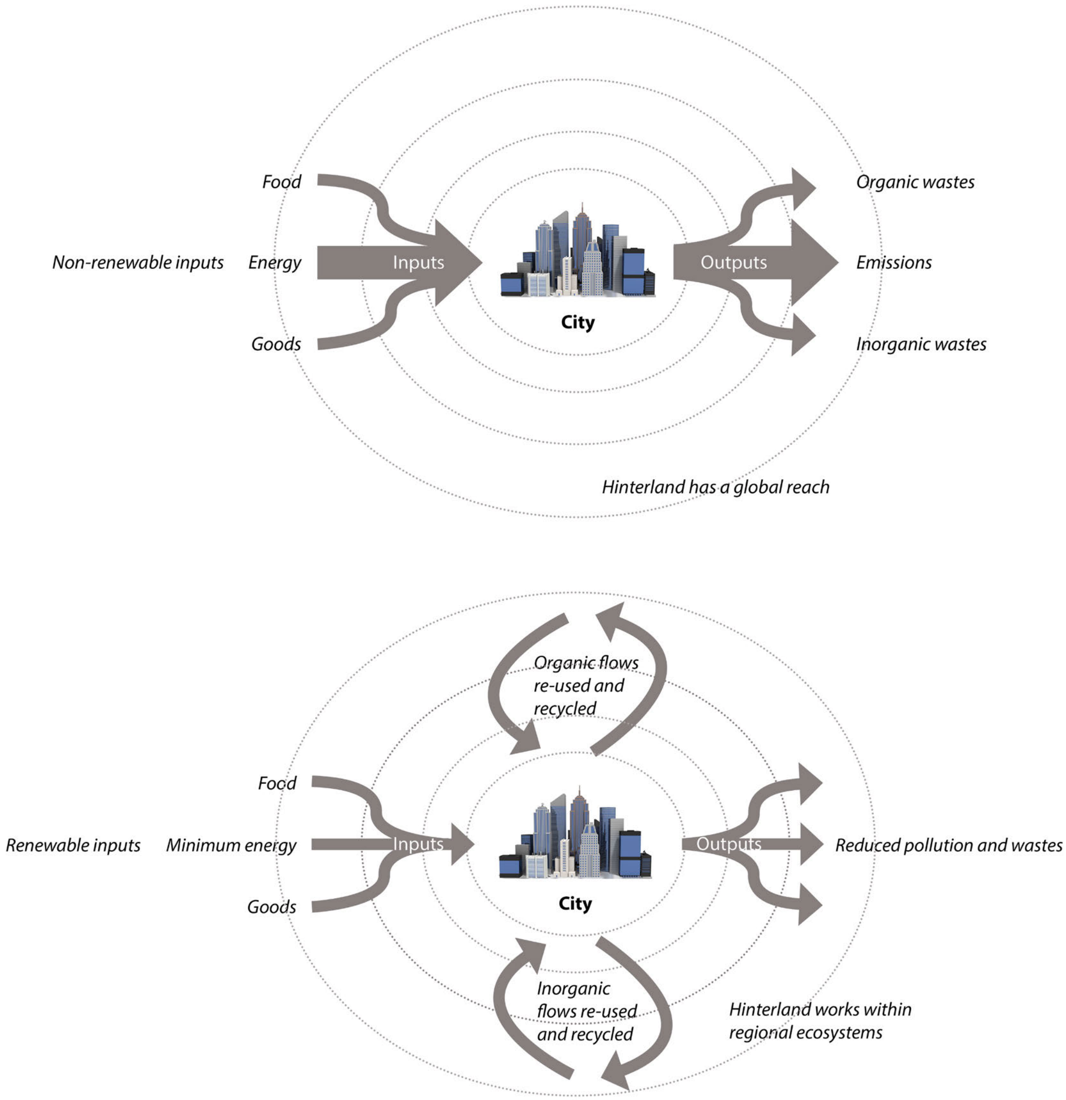

FIG. 2.2 Linear and circular metabolisms of cities (van Bueren, 2015). Adapted from Rogers and Gumuchdjian (1997).

The taking up of circular cities by the IE communities is no coincidence, as sustainable resource use and the closing of loops is key to IE. This has also brought a strong emphasis on resource flows. Within this community, the circular city is mainly examined as a technical artifact that converts natural resources in a way that needs changing. Despite the fact that circular cities are only one application of the concept of circularity and many others can also be linked to it (e.g., an economic sector that should become circular, a specific circular region), circular cities are the most popular. The main explanation is that we now live in the so-called 'urban age' (Brenner & Schmid, 2014), as more than half of the human population lives in urban areas. Next, increasingly cities have gained agency as centres of value creation in economic and cultural perspective (e.g., Florida, 2005), which in turn also led cities to organize and empower themselves in fora such as the Global Parliament of Mayors[4] or the Resilient Cities Network[5].

Nonetheless, authors have claimed that focusing on the circularity of material flows without a reference to social and economic processes is problematic (Corvellec et al., 2021; Korhonen et al., 2018b). One could also question if the focus on circular cities, without a reference to the 'outer city' or hinterland is the way forward. Many environmental problems are transboundary: they do not stop at borders, hence the environmental problem and solution of cities, being it a circular city in this case, will most likely only be achieved if we are able to improve our perspective of the city, beyond the late 19th and beginning 20th century perspective. Whether more recent academic proposals to define a circular city past centuries ethe is examined in the following section.

4 See https://globalparliamentofmayors.org/

5 See https://resilientcitiesnetwork.org/

2.5 Circular cities: existing perspectives

Despite the lack a commonly accepted definition, circular cities receive political and public attention and of policy makers. Different international organizations, governments, firms, and scholars have come up with perspectives regarding what a circular city entails.

Among international organizations, the EMF is arguably the most prominent private actor fostering a circular approach to cities. The EMF understands a circular city as one that thrives in the long-term, bringing prosperity to its citizens while respecting the planetary boundaries. For the EMF cities provide a workable system boundary for action. Special attention is put on buildings, mobility, products and services, and food systems (EMF, 2017a). The C40 network of megacities has also put attention on circular transition at the city level. They provide a concept based on long-lasting resource use, maximum value extraction, recovery and regeneration of product and materials at the end of their lifecycles (C40, 2018). Similarly, but less straightforward, the United Nations' (UN) "Waste Wise Cities" initiative is arguably its closest attempt to a circular city perspective. In this initiative, among 12 principles aimed for coping with the ever-increasing global waste management crisis, a call for designing incentives to promote a CE in cities is included. Although a circular perspective to cities may be linked to UN's Sustainable Development Goal 11 on sustainable cities and communities, the international body does not provide a circular city concept.

Some firms have also started to work with circularity in cities. Prominent work has been done by young Dutch consultancy firms. Both organizations have guided dozens of cities, especially in the EU, in their intention to become more circular. Their approaches focus on identifying crucial resource flows in city areas to be used to create visions and agreements among local stakeholders to close resource loops and minimize resource use (Circle-Economy, 2017; Metabolic, 2021).

National and local governments have also established their own strategies for circular cities, regions, and countries. For instance, in Europe, several countries and cities have already launched their visions and strategies towards a more circular economy. The European CE Stakeholder Platform by the European Union (EU) offers a policy repository wherein more than 40 city and national level strategies can be found, most of them including construction, buildings, infrastructure and/or city's daily operations as part of their scope[6].

6 See https://circulareconomy.europa.eu/platform/en/strategies?populate=.

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The last five years are characterized by a growing number of academic attempts towards a circular city conceptualization. We now discuss the conceptual directions towards circular cities as provided by eight recent and already well-cited publications. Together, they give an impression of the width and depth of the conceptual development of circular cities. Petit-Boix and Leipold (2018) reviewed CE initiatives in cities and grouped them according to four urban targets: infrastructure, social consumption, industries and businesses, and urban planning. They looked at the number of city initiatives in place, leaving out the degree of effectiveness of their implementation, and found that while cities themselves focus mainly on urban infrastructure, circular city research is mainly concerned with industrial and commercial practices. They concluded that more attention should be put on social consumption, urban planning, and how to define the environmental impact of adopted circular strategies at the city level. Gravagnuolo et al. (2019a) identified sectors for circular city implementation. These are the built environment, energy and mobility, waste, water, industrial production, agri-food, and citizens and communities. Their idea of a circular city is that of self-sustainable systems that require not only technical and business innovation, but a cultural paradigm shift characterized by changes in governmental organization and educational structures by which the city works cooperatively to create niches of circular innovation. Specifically on governmental aspects, Bolger and Doyon (2019) analysed the role of strategic planning and resource management at the local scale to promote CE strategies. After identifying ways by which two different municipalities are integrating strategies in their planning instruments, they pointed out the difficulties posed by the absence of a clear circular city framework, as well as the need for introducing circular thinking in urban planning and to understand the role of different levels of government in sustainability urban transitions. Although the above-mentioned characterizations provide insights or directions towards a circular city concept, the authors agree on the fact that such a shared concept is still lacking.

Some authors do provide more concrete concepts. Fusco Girard and Nocca (2019) claim that the circular city is a metaphor to illustrate the functioning of a city as that of natural systems (cf. Wachsmuth, 2012). More particularly, a circular city is the territorialization of the CE, a human-cantered system wherein resources are recycled, and the use of primary resources are minimized. The built environment of a circular city is or should be therefore constructed in a flexible and modular way. Kębłowski et al. (2020) see circular cities as a promise of fundamental change towards the re-territorialization of production, distribution, consumption, waste management and innovation, although such promise is restricted by major capitalistic ways of production. Paiho et al. (2020) focuses on actions tending to either close, slow, or narrow resource loops in the urban space. Yet, these actions are only applicable *'after the potential for conservation,* *efficiency improvements, resource sharing, servitisation and virtualization has been exhausted' (p. 6).* Localisation of production and productive processes powered by renewable energy are also inherent to their understanding. A more comprehensive conceptualization is given by Williams (2019a, p. 10), who defines the city as a '*complex, heterotrophic artificial ecosystem in which resources are produced and consumed by a variety of activities, initiated by inter-dependent actors, across multiple sectors and scales*'. Hence, whatever the changes a circular approach to cities intends to accomplish, they must be understood in a context of ever-changing demands, patterns of consumption and systems of provision. The basics for circular city functioning will be determined by three circular actions – Looping, regenerating, and adapting –, and four supporting actions. – optimisation, sharing, substitution and localisation (Williams, 2021).

The publications discussed in this section show similarities, differences, and research directions of the circular city concept. A central common ground is provided by the need for identifying relevant systems of provision, production and consumption, and scales of circular intervention. This resonates with the historically developed systemic view of cities, not only as urban systems fuelled by their hinterlands, but as a process governed by the interplay of different stakeholders, space, institutions, and resources. A marked difference among authors is the tendency to either encapsulate the concept of circular city as the implementation of R-strategies in urban areas or expand it to embrace aspects such as territorial planning, ecological regeneration, and multiple levels of governance. The quest for a circular city concept is another difference. While some authors approach circularity in cities through the identification of circular initiatives, others attempt to provide circular city definitions to test its operationalization. As this conceptual examination is not exhaustive, bibliometric analysis may offer broader perspectives on circular city research and understanding.

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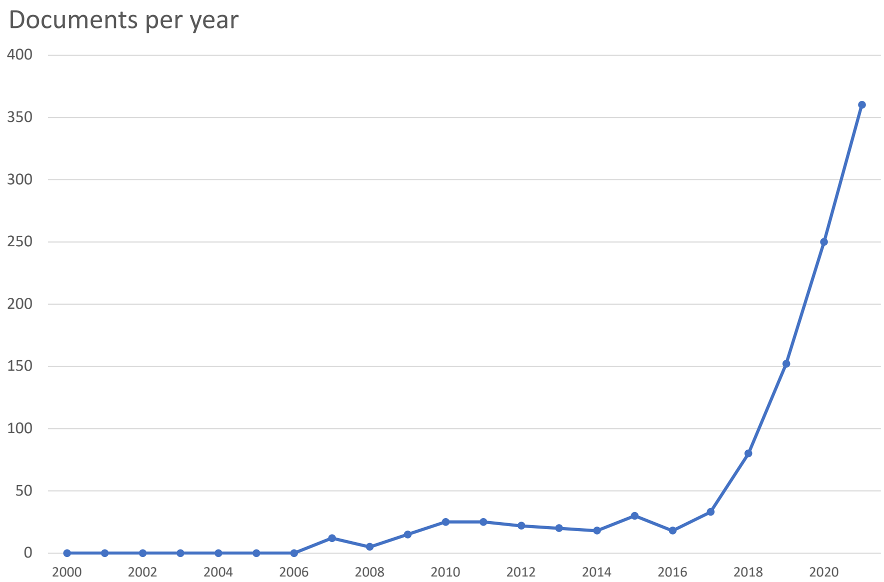
2.6 Bibliometrics

The evolution of circular cities research can be traced by looking at major research databases, such as Scopus. This section shows the results after searching for [‘circular economy’ AND (‘city’ OR ‘cities’ OR ‘urban’)] in titles, abstracts and keywords. This search string resulted in 1,059 documents between 2000 and 2020, as for March 26th, 2021. Firstly, publications increased from less than 30 in 2015 to more than 350 in 2020. Secondly, about 60% of results correspond to articles, 21% to conference papers and 7% to reviews. Thirdly, most contributing countries are China, Italy, United Kingdom, Spain, The Netherlands, United States and Germany. Fourthly, when it comes to affiliation, most documents are linked to Delft University of Technology, Chinese Academy of Science, and Università degli Study di Napoli Federico II, respectively. Fifthly, in terms of subject areas, environmental science (26%), social science (14%), engineering (14%) and energy (12%) are most predominant. Finally, funding sponsors have mainly been the Chinese government and the European Union. Figure 2.3 and 2.4 shows four resulting graphs of our search in Scopus.

The findings provided by this bibliometric analysis help the reader to situate circular city research by pointing out who is contributing to research, which institutions lead its scientific progress and what governments have invested in major research funding. There is a clear link between the governmental bodies that have included the circular economy in their political agendas, the geographical location of the institutions where research takes place, and the authors that produce research output. Williams (2021) claims that circular cities are a European phenomenon, yet the bibliometric findings show that China is among the major contributor to circular city research. These findings may also be seen as a reminder of the essential role of governments in fostering and incentivizing more circular systems of production and consumption. However, this bibliometric analysis is blind to the contributions of the private sector globally. This is worth noting as the circular economy is characterized by ever-increasing reports from consulting firms (Kirchherr et al., 2017).



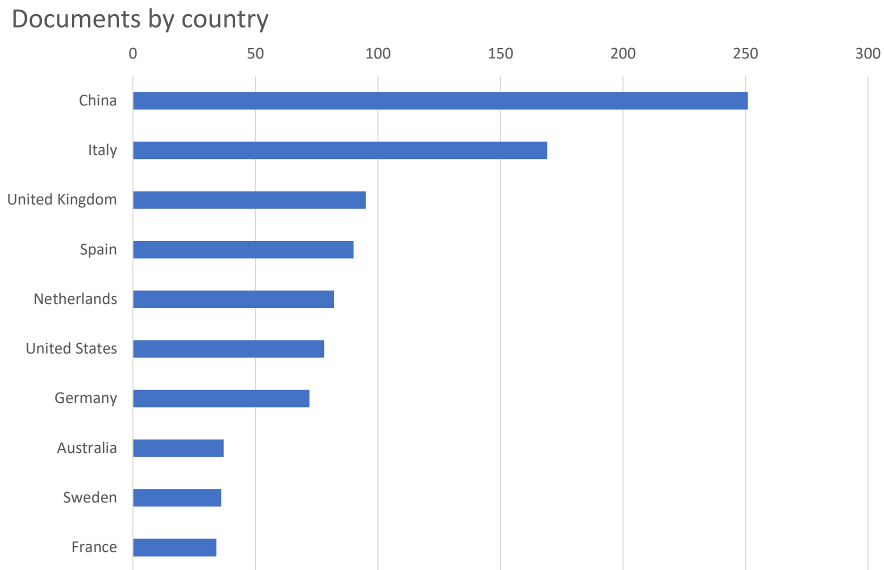


FIG. 2.3 Circular city bibliometrics sorted by year (above), country or territory (below). Retrieved from Scopus, March 26th, 2021.

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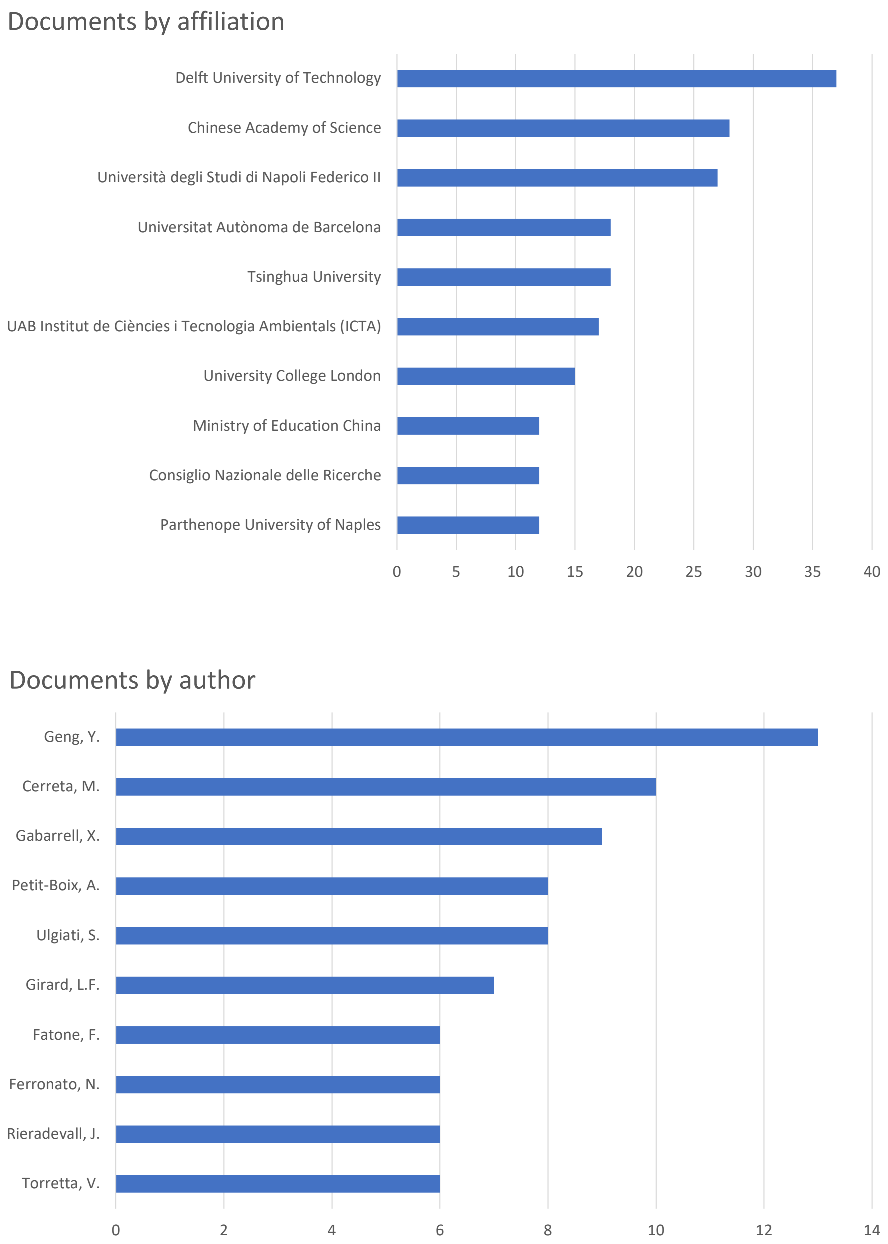

FIG. 2.4 Circular city bibliometrics sorted by affiliation (above), and author (below). Retrieved from Scopus, March 26th, 2021.

2.7 An outlook of circular cities: barriers and challenges

Translated into policy, in general, circular cities tend to focus on the waste of the construction sector, organic waste and consumer goods (Williams, 2021) – all three accounting significantly for the ecological impact of cities. In accordance with this, several existing and new developed frameworks have been proposed to understand and facilitate the journey in improving cities' ecological impact. These frameworks are the R-frameworks, focusing on the waste (prevention) hierarchy, or more recently the ReSOLVE framework by EMF et al. (2015), which builds around six actions to businesses shifting towards circularity, namely: regenerate, share, optimise, loop, virtualise, and exchange. Consequently, within the policy documents of circular cities, these frameworks are often mentioned and operationalized.

The challenge of implementing more circular cities is quite significant. As shown in figure 1, a circular city lies on the confluence of the local and global. It involves a systemic change of the current consumption and production system at global level, and at local level a change of the locations where production and consumption take place, changing the material and immaterial design of those places. In this article, the reviewed academic and policy sources on circular city concepts show that technical, ecological/environmental, and social aspects are all addressed. The main challenge, however, is a political one, and deals with scales and responsibilities. A circular city is a normative concept, implying that there is an ambition to change the current (linear) consumption-production system. As explained, this involves the conceptual – and eventually operational – confluence of scales. Questions to address are: What should be organised on what scale and when? Who is responsible?

There is by no means an easy answer to these questions. It is a utopia that all relevant circular functions can be located within a particular city to match the consumption and production – cf. an autarkic system. Even a circular world will remain a globally connected world (Burger et al., 2019), though most likely differently organised than today. For a circular city it is essential to localise functions conditional and in support of a CE, such as remanufacturing, logistics, and agriculture; functions that are essential to process and supply the demand of (circular) materials. Without such functions, circular city policies risk becoming no more than marketing talk – or a 'circular washing' of traditional good housekeeping and end-of-pipe waste reduction strategies. Key to circular cities is thus the question of what circular functions and what kind of (im)material flows cities should '(re)capture' or (re)manufacture and on what scale this should be organised? Consequently, what scale comes with which responsibility? And are there scales and locations that do not and/or cannot take up this responsibility? Again, it is a utopia that all materials and the processing of these can remain within a certain region – for example, to create a circular built environment- as well as it is a utopia that loops can be closed without leakages and without negative environmental effects. Consequently, the extent to which a circular city can become a reality, will to a large extent depend on what other – institutional – places decide to do. The plastics case can serve as an example. At the time of writing, 2021, many Western-European cities, regions and countries have optimised the collection and separation of plastic, with the idea that this would improve the reuse of those materials. However, the plastics processing plants are located in other non-Western places, places – as it was revealed – with less strict environmental and labour regulations. In reality, much of the plastics arrived at landfills (see for more information Ananthalakshmi & Chow, 2019). This example shows that the policy goal of one place should consider the whole (re)supply production chains of products.

Eventually, the insights provided in research and policies for circular cities add up to the argument of Williams (2021) that for circular cities not materials, but space is the key concern. Space to accommodate – extra – functions that enable matching the consumption and production within a circular (urban) economy; space that is scarce in these densifying urban areas with rising land prices due to continuing urbanization.

2.8 Conclusion

Circular cities are increasingly a popular concept and policy goal. This chapter has given a brief overview of the conceptual origin of the concept and explained why in some cases it is difficult to match consumption and production on an urban scale. We explained that a circular city is where different scales come together – cf. the location of circularly designed products or buildings, and circular economic systems. The former cannot exist without the latter, and vice versa. It is, however, a utopia that both can fully be accommodated in a limited space of a city. The way forward towards circular city development is not so much a conceptual or technical challenge, but primarily a political one. A circular city, a city with a normative goal to become more circular, must find out for itself what is essential to move towards this policy goal (Van den Berghe & Vos, 2019). Exchange of the experiences with circular city development amongst cities, practitioners and academics will contribute to conceptual clarity, which in turn will provide guidance in the fragmented governance setting in which circular city policies are formulated and implemented. Summarized, the main challenge is how circular cities can go beyond the marketing of the circular city concept and effectively take up their responsibilities that come with the scale they are operating on.

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3 Policy instruments for a circular built environment

A systematic literature review

Adapted from: Bucci Ancapi, F., Van den Berghe, K., Van Bueren, E., (2022). The circular built environment toolbox: A systematic literature review of policy instruments. *Journal of Cleaner Production*, 373 (1), pp. 1-12.

3.1 Introduction

Integrating circular economy (CE) strategies into the built environment (BE) has been identified as crucial for sustainable urban transitions (Schröder et al., 2020) since the BE is a major global resource consumer and polluting human activity (Ness & Xing, 2017b; Pomponi & Moncaster, 2017; van Bueren, 2009). In 2020, global anthropogenic mass (the mass embedded in all human-made objects) surpassed that of global biomass. Most of this mass comprises materials in the BE –e.g., concrete and aggregates such as gravel, and bricks. The total mass of buildings and infrastructure is thus greater than that of trees and shrubs, and that is without considering anthropogenic mass waste (Elhacham et al., 2020).

At different scales, a variety of concepts, measurements and tools are used to express or measure the BE's performance in terms of flows of materials and energy, the key indicators of a circular BE (CBE): urban metabolism, material flow analysis, input/output analysis, and lifecycle assessment, among others. Although these environmental concepts, measurements and tools are essential for understanding the extent to which the BE is circular, and what the opportunities are for making it more circular (Kaviti Musango et al., 2017; Lucertini & Musco, 2020), a predominant perspective on environmental performance (Kirchherr et al., 2017; Munaro et al., 2020) may not inform us on how to bring about a CBE (Pomponi & Moncaster, 2017). For instance, these concepts, measurements, and tools neglect political, social, economic, and behavioural aspects, which are known to present essential barriers and drivers to systemic change (Korhonen et al., 2018a; Schröder et al., 2020). In particular, the challenges in the governance and management of CBE and the transitions needed in policy making, including the roles of governments and industry, are under-researched (Munaro et al., 2020).

However, policymaking for systemic sustainable change or transition in the BE, with the aim of bringing about a CBE or otherwise, is challenging, both conceptually and empirically. While change in the BE as a research object has received increased attention in the last decades, a clear and widely accepted conceptualization of the 'BE' itself is still lacking. Moffatt and Kohler (2008, p. 249) define it as the *"manmade surroundings that provide the setting for human activity, ranging from the large-scale civic surroundings to the personal places"*. Yet, they claim that the only way to really define the BE is in opposition to the *un*-built environment, or the biosphere. Other authors approach it from its 'constituting elements', namely: buildings and infrastructure (Hart et al., 2019). In a BE-specific research methodology book (Knight & Ruddock, 2008) it is not defined explicitly but referred to as the object of construction management. Similarly, in recent research frameworks put forward for the analysis of CE in the BE, the authors' understanding of the BE is not specified but rather used loosely to describe (components of) the building sector or the research field (Munaro et al., 2020) at different scales, starting from objects to buildings to urban agglomerations (Pomponi & Moncaster, 2017).

In the report 'From principles to practice: first steps towards a CBE' by the Ellen MacArthur Foundation (EMF) (2018), the CBE is conceptualised as reaching well beyond mere buildings and construction to include that it has to: (1) support human-wellbeing and natural systems; (2) be guided by system thinking; (3) be leveraged by digital technology; (4) implement holistic urban planning; (5) foster continuous material cycles; (6) design for maintenance and deconstruction; (7) provide flexible productive buildings; and (8) combine integrated infrastructure systems. The EMF has also introduced the "ReSOLVE" framework for businesses and countries willing to move towards a CE, which stands for Regenerate, Share, Optimise, Loop, Virtualise, and Exchange, as six main circular actions for policymakers (EMF, 2015). However, creating effective policies that address these actions for the circular transition of the BE involves multi-level decision making by a variety of actors, usually with conflicting interests, operating in various markets (van Bueren & Priemus, 2002) within different physical and administrative boundaries (van Bueren & De Jong, 2007a).

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The understanding of the BE gets even trickier when the policy goal of a circular city is introduced. In general, a circular city has the goal of improving the ecological impact of existing in- and out-going flows of materials and energy in urban buildings and infrastructures by making them as circular as possible (Bucci Ancapi et al., 2022a). It is therefore not a coincidence that the BE is linked to an urban dimension rather than to a rural one. Cities are expected to concentrate more than 60% of the global human population by 2030, and though they occupy only 3% of Earth's land, they are responsible for 60-80% of global energy consumption and up to 70% of human-induced greenhouse gas (GHG) emissions (UN, 2020). Consequently, circular cities have become a focal policy concept for different international organizations, such as the United Nations (Kaviti Musango et al., 2017) and the European Commission (COM, 2020), for governments –e.g., China, the Netherlands, Belgium, Chile– and for scholars (Keblowski et al., 2020; Marin & De Meulder, 2018; Paiho et al., 2020; Pomponi & Moncaster, 2017; Thelen et al., 2018; Van den Berghe & Vos, 2019; Williams, 2019a).

3.2 Literature review: policy (instruments) in circular built environment research

There are a wide variety of concepts, frameworks and measurements related to BE, CBE and circular cities. Inevitably, this has consequences for policymaking. The apparent interchangeability of CBE and circular city concepts makes it difficult to come up with clear and effective CBE policies and policy instruments. It is acknowledged that the relationship of CBE ambitions with policies and policy making are often over-looked (Munaro et al., 2020; Pomponi & Moncaster, 2017). Certainly, the governance of circular economies is covered in research. Some examples are the case of international comparisons about the effectiveness of governance in relation to CE (Cramer, 2022), policy mixes for advancing towards a CE (Milios, 2018), and the analysis of institutional drivers and barriers of circular economies (Ranta et al., 2018). Recently, some authors have investigated the relation between the construction industry, circularity, and policymaking, approaching CBE governance challenges in relation to the so-called policy cycle (Yu et al., 2022). Bucci Ancapi (2021) analysed the relation between BE, circularity, and policy instruments, providing a general classification of policy instruments in relation to CBE that distinguishes regulatory, economic, and information instruments.

While Yu et al. (2022) state the importance of policy instruments and synergetic policy mixes to bring about a CBE from a supply chains perspective, and Bucci Ancapi (2021) provides a preliminary policy instrument analysis for CBE implementation based on a review of academic literature, none of them conceive the BE as a distinct element of cities and urban development. Rather they follow the mainstream understanding of BE as a matter of construction management, and circularity as making supply chains more sustainable. Therefore, there is a lack of understanding concerning the role of CBE in circular city development. Accordingly, the aim of this research paper is to provide an analysis of what CBE policy instruments are discussed and proposed to implement a CBE from a circular city development perspective, based on a selection of relevant scientific publications. This leads to our research question: what is the current understanding of the relation between CBE and policy instruments needed to bring about a CBE?

To answer this research question, the remainder of this article is structured as follows. Firstly, we explain how we define policy focused on CBE in relation to circular city development and introduce the analytical framework by Williams (2021) used to analyse our empirical results. Secondly, in our methodology section we explain the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines (PRISMA) (Moher et al., 2009) that we applied as research protocol for our literature review. Thirdly, we present the results of the systematic literature review. Fourthly, we discuss the role of policy instruments in implementing CBE, and the required coherence between different policy instruments to improve the effectiveness of radical societal changes, such as the CE transition. We do this by answering the following sub-research questions: (1) how many publications elaborate on CBE policy instruments; (2) what type of circular actions in relation to circular city development are mentioned; and (3) what policy instruments are proposed to implement a CBE? Finally, we provide both conclusions from the review and policy recommendations to improve the effectiveness of CBE policy goals.

3.3 A framework for analysing policies and instruments for circular built environment

Prior to our analysis, we need to fulfil two analytical requirements. Firstly, we need a framework to understand the contributions to the CBE that the policies mentioned in our selection are making, and, secondly, we need a framework to understand the type of policy instruments mentioned.

An effective implementation of CBE requires contextualization. We argue that such contextualization is possible through the circular city concept, for a BE does not exist without the complex adaptive system that creates it: the city. As explained by Bucci Ancapi et al. (2022a) many scholars have recently studied different urban phenomena from a circular city perspective, yet relatively few authors have provided a conceptualization of what a circular city entails, and even fewer propose a comprehensive framework for circular city transitions. Among the available frameworks, the one by Fusco Girard and Nocca (2019) is worth noting, as it proposes a set of indicators for circular city implementation based on both theoretical papers and case studies of specific circular city programmes, strategies, or agendas. Such indicators emerged as a response to a generalized lack of assessment of the effectiveness of cities' policies moving towards circularity. From another perspective, Paiho et al. (2020) sought to conceptualize the circular city, and to point out what indicators and tools are available for planning a circular city. In summary, although a few circular city frameworks elaborate on policy-related topics to CBE, we conclude that, firstly, they do not give an overall typology of policy instruments and, secondly, do not inform us about how these policies can be operationalized through instruments to implement a CBE.

A recent publication by Williams (2021) offers a feasible way to understand both the contributions of policy to the CBE and a typology for policy instruments, the focus of our article. Williams (2021, p. 157) argues that "*circular cities are urban systems in which resources are looped, the ecosystem is regenerated, and the socio-technical systems (infrastructure and communities) evolve with changing contexts. Thus, circular cities are resource efficient, resilient and operate within the global carrying capacity*". Cities shifting towards circularity do so through circular development, which Williams (2021) understands as the process which integrates three circular actions –i.e., *looping* actions, ecologically *regenerative* actions, and *adaptive* actions– into urban systems of provision (Figure 3.1).

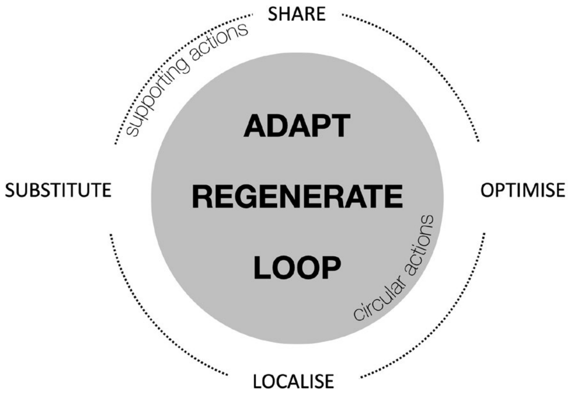

FIG. 3.1 Circular city development. Adapted from Williams (2021).

Looping actions relate to the commonly known waste hierarchy and value retention options, also known as 'R-imperatives or strategies' (Prins & Rood, 2020; Reike et al., 2018; Savini, 2019) of sustainability, such as energy *r*ecovery, *r*ecycling and *r*euse of resources. Ecologically regenerating actions seek to regenerate the urban ecosystem and the provision of ecosystem services, actions normally linked to the implementation of blue and green infrastructure –e.g., green roofs and rainwater storages facilities. Adaptive actions aim to capacity building among communities to adapt to change –e.g., through collaborative planning. Some opportunities given by circular cities are to close resource loops, to enable people's reconnection with nature, the protection and enhancement of ecosystem services, to create adaptive cities and to enable learning within and by communities. Williams (2019a) also introduces four urban supporting actions, namely: optimization, sharing, substitution and localization. However, as stated from case studies, Williams (2021) shows that most cities in their circular transition focus solely on local looping actions for organic and construction waste streams, and focus their attention on integrating CE actions rather than aiming for broader circular development or systemic change. The focus on looping actions has enabled the identification of usual challenges in their implementation, which are linked to the lack of: political support; an integrated and supportive framework for regulation and standardization; data; and institutional capacity (Williams, 2019b). Yet the three circular actions are meant to work synergistically to deliver circular development (Williams, 2021). Whether or not such synergies happen should be the subject of study and not taken for granted. European case studies have shown how cities may fail in implementing more ambitious circular and sustainable strategies in general as they are locked-in to low waste hierarchy strategies such as waste-to-energy systems (Van den Berghe et al., 2020; Williams, 2021). The circular city development framework by Williams (2021) based on three circular actions and four supporting actions will thus be used in this article

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as our analytical framework to analyse the relation between policy instruments and CBE implementation, as stated in academic literature. We argue that without a holistic perspective, the CBE transition is hindered by unbeneficial reductionism, such as mainstream technocratic approaches that see circularity as a matter of getting resource flows right (Newell & Cousins, 2015; Wachsmuth, 2012). Therefore, seeing the BE from a city perspective enables a circular development beyond mere resource efficiency, for adaptive and regenerative capacities to climate change and ecological debacle are also considered to deliver urban sustainable development.

3.4 Methods

3.4.1 Literature search

For this article, we adhered to the PRISMA guidelines to conduct a systematic literature search. PRISMA is the result of an analysis about available methods and tools for the process of systematic literature search and review originally developed within medical studies (Moher et al., 2009). Because of its reporting meticulosity, PRISMA is increasingly being used in social science and qualitative research –i.e., De Vries et al. (2015), Sadick and Kamardeen (2020) and Huijbregts et al. (2021). The PRISMA guidelines make use of a checklist and a flow diagram to summarize the process of study selection in terms of identification, screening, eligibility, and inclusion. Both the checklist and flow diagram enable a rigorous review that can be checked and replicated by others.

As eligibility criteria, considering the existence of previous reviews for CE in the BE of Munaro et al. (2020) and Pomponi and Moncaster (2017), our intention is only to address its policy perspective, avoiding those including so-called circular strategies (Potting et al., 2017) –i.e., reduce, recycle– in previous BE research and policy without a clear CE framework –i.e., publications based on waste or environmental management. The following criteria have been established. Firstly, from the literature search we will only consider published open access articles, reviews, and book chapters available in the selected online databases, so as to ensure full replicability of our results. Secondly, the period 2010-2020 was chosen because it guarantees that eligible early developments in the BE in China, Japan, United Kingdom, Germany, and European countries in general, as CE frontrunners (Geissdoerfer et al., 2017;

Munaro et al., 2020), are considered. Thirdly, eligible manuscripts must be written in English. Fourthly, the words 'polic*', 'govern*', plan*', 'lever*' or 'manag*' must be included either in the text's title, abstract or keywords. We acknowledge that this selection criteria may lead to the omitting of relevant articles, reviews, and books; however, it ensures that only manuscripts explicitly linked to the field of CE in the BE are covered, thus reducing bias in the selection process. It is important to highlight that these decisions frame the main assumptions and simplification in our data collection process and are derived from using 'circular* economy', 'built environment', 'city OR cities', 'manag*', 'polic*', 'govern*', and 'plan*' as criteria for exclusion. There might be articles, reviews, and books that implicitly address policy related aspects of CBE that were not considered in our review.

Our systematic literature search strategy is presented as follows. We searched two online databases, namely: Web of Knowledge and Scopus, to ensure a wide pool of scientific inputs in our literature search. The search was conducted on April 29, 2021. We searched for the strings *"circular* economy" AND "built environment"* and *"circular* economy" AND ("city OR cities")*. In Web of Science, we selected the field 'topic', which searches authors, abstracts, and keywords. In Scopus, we selected the field 'Article title, Abstract, Keywords'. Only articles, reviews and book chapters were included in the search. The resulting findings were exported as RIS, CSV and Plain text files containing full information. They were stored and analysed using EndNote's X9 to further identify those publications containing 'polic*', 'govern*', plan*', 'lever*' or 'manag*'. Data extraction was done manually and independently by the authors. Cross-checks were performed by the authors to ensure a correct data extraction.

3.4.2 Policy instrument analysis

The circular city development framework has also been selected for it provides a set identified policy instruments or levers gathered from case studies in Europe. Williams (2021) identified commonalities among the circular development pathways of Amsterdam, Stockholm, Paris, and London. The main trends highlighted are the evident economic and environmental motivations to pursue circular development, the tendency to focus on looping actions for organic and construction waste streams, and the renewal of grey infrastructure by blue-green ones. There are also commonalities in levers for implementation, as instruments for capacity building, regulation, fiscal arrangement, and land or financial incentives. Policy instruments are divided into four main categories: regulation, provisioning, capacity building, and financial incentives (Table 3.1).

TABLE 3.1 Levers for circular city development. Based on Williams (2021).

Regulation	**Legislation**	**To encourage circular actions and circular development**
	Policies	**Policy targets and policies for encouraging circular actions and circular development**
	Contracts	Tendering, contractual agreements, environmental programmes to enforce circular development principles
	Planning	Spatial plans, integrated plans, temporary planning permissions, flexible planning, performance-based planning & collaborative planning to enable circular development
Financial incentives	**Local currencies**	**To encourage circular activities or the localised looping of resources**
	Pension funds	**Invested in circular businesses, services, and infrastructure**
	Capital and operational subsidies	For circular infrastructure and circular activities
	Taxation	To reduce waste and encourage circular activities
	Public procurement	To encourage the development of circular products and services
Provisioning	**Municipal provisioning**	**Of services and infrastructures to enable a circular transformation**
	Co-provisioning	**State/private sector partnering with the community to provide circular systems of provision**
Capacity building	**Experiments and living labs**	**To determine the challenges to circular activities and circular development**
	Coordination and logistics	**To enable circular actions across city-regions**
	Data platforms, training, and tools	To enable learning, exchange or resources and enforcement of circular actions
	Fora and networks	To enable learning and coalitions to be built to enable circular actions
	Provision of land	For circular activities

In addition, we resort to knowledge on the appropriateness and effectiveness of the use of distinct types of policy instruments to enable a more meaningful discussion. This decision was taken as the levers identified and classified by Williams (2021) are arguably specific policy instruments, and not an actual typology of the latter. Hence, we use the work of Vedung (1998) as his classification is the most frequently used instrument typology in environmental policy as policy field to date (Acciai & Capano, 2021). Vedung (1998) provides a threefold typology of policy instruments: *regulations* – rules and directives mandating receivers to act in accordance with that is ordered in them –, *economic means* – both the taking away or handing out of material resources of all kinds –, and *information* – measures undertaken to influence people through the transfer of knowledge, communications, and persuasion (Vedung, 1998, p. 51).

3.5 Results

3.5.1 Literature search

A total of 166 articles, reviews, and book chapters met the afore-mentioned selection criteria and were included for analysis, representing 53% of the total 314 publications initially identified after duplicates were removed (Figure 3.2).

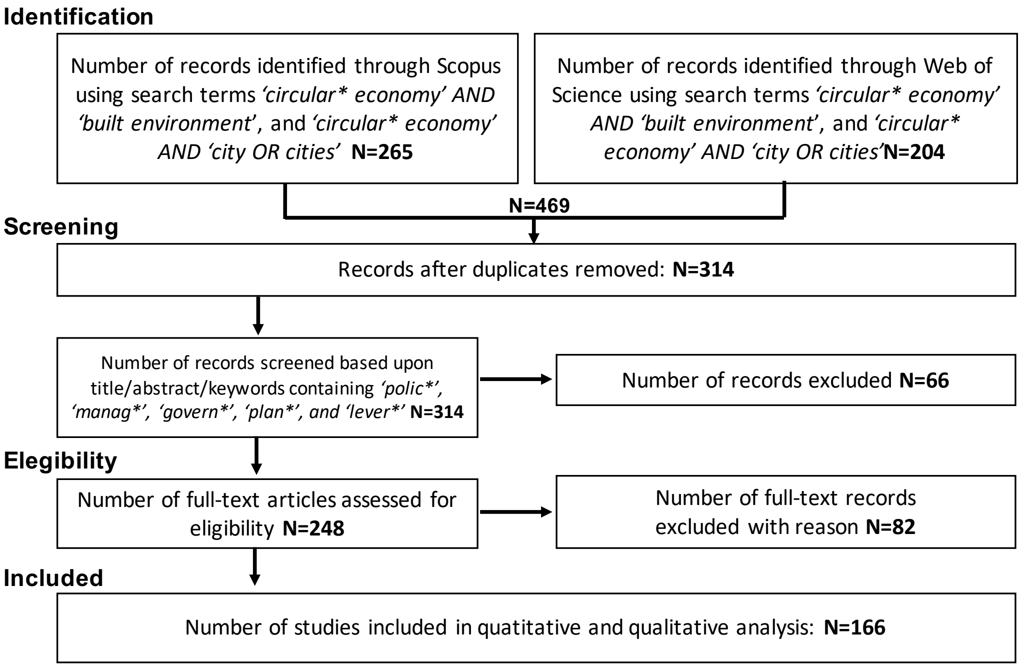

FIG. 3.2 Information flow for final selection of studies included in review, based on the PRISMA guidelines. Search date April 29, 2021.

The reasons for further exclusion of full-text records can also be found in the data set published in the 4TU.ResearchData repository[7], which contains the complete list of publications and the analysis carried out. 144 (87%) publications correspond to articles, 4 (2%) to book chapters and 18 (11%) to reviews. In terms of most contributing journals, Sustainability (Switzerland) provided 52 publications, followed by Journal of Cleaner Production with 11, and Journal of Resource Conservation and Recycling with 7. Except for 5 publications, all of them were published between 2016 and 2020 (Figure 3.3). 117 articles used qualitative research designs, while 80 quantitative ones, and 29 mixed methods. 119 publications (72%) resort to case studies, being China (n=19), Italy (n=19), The Netherlands (n=12), Spain (n=11) and United Kingdom (n=9) the countries with most case studies.

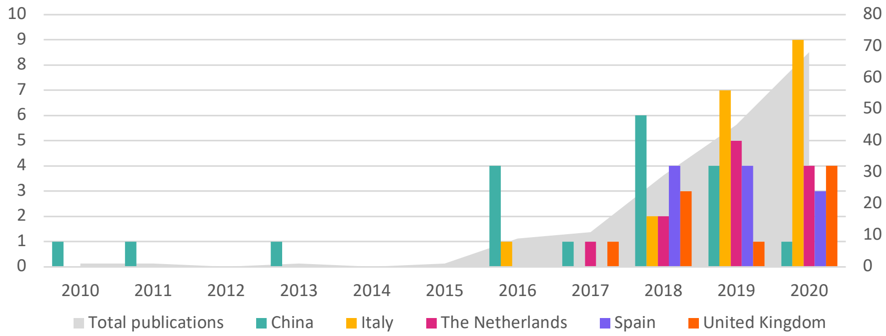

FIG. 3.3 Yearly publications from 2010 to 2020 for the final literature selection (N =166). On the right axis, the number of case studies per country, on the left axis the total number of publications for the selected period. Source: the authors.

A co-occurrence analysis was conducted to identify the most used keywords in the final literature selection. By using VOSviewer we created Figure 3.4, only keywords with at least 5 occurrences were included. The main keywords identified were “circular economy”, “waste”, “sustainability”, “city”, “waste management”, “circular city’, “smart city”, and “economy”. Main keyword co-occurrences link “circular economy” with “waste”, “waste management”, “city”, and “sustainability”.

7 https://doi.org/10.4121/19626861.v1

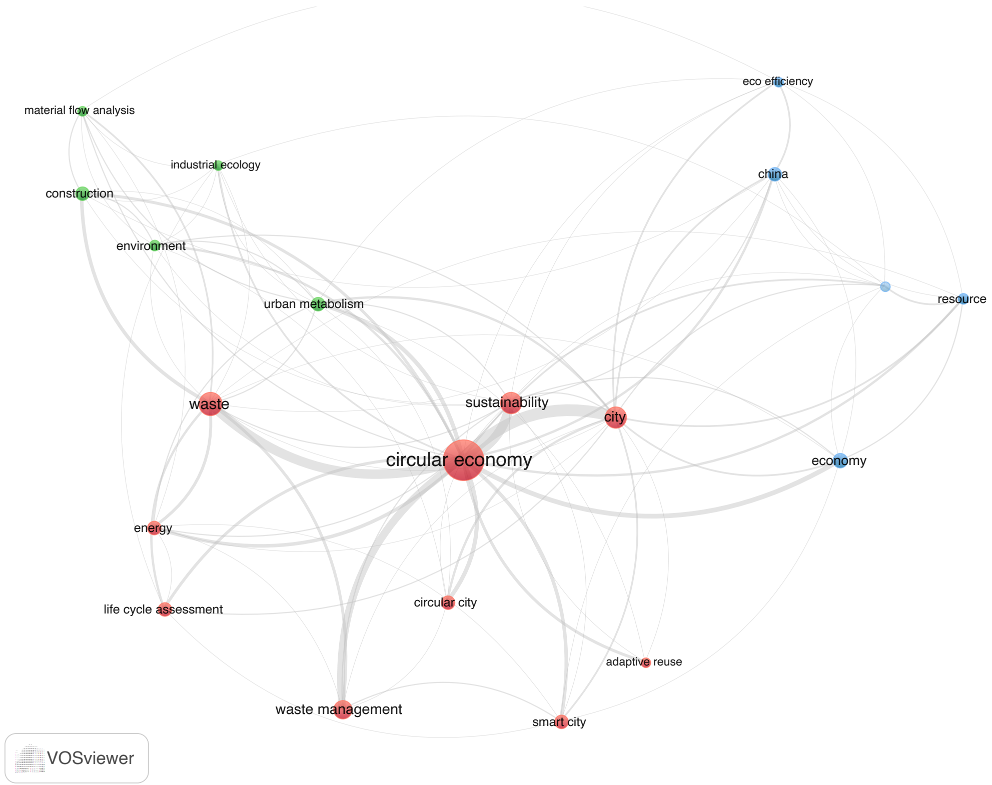

FIG. 3.4 Keywords co-occurrence network for final literature selection (N=166). Made with VOSviewer, co-occurrence threshold = 5, colour clusters are automatically assigned by the software. Source: authors.

3.5.2 Findings according to circular actions

In relation to Williams (2021) circular city development framework, the resulting sample was analysed and sorted out in terms of *circular actions* –looping (n=119), regenerative (n=24), and adaptive (n=50)–, *supporting urban strategies* –localize (n=90), optimize (n=59), share (n=21), substitute (n=55)–, and *levers for circular development* –regulation (n=120), financial incentives (n=30), provision (n=29), and capacity building (n=60) –, respectively (Figure 3.5).

There is no doubt about looping actions being the most developed in our sample. Table 3.2 shows the most discussed themes we identified:

TOC

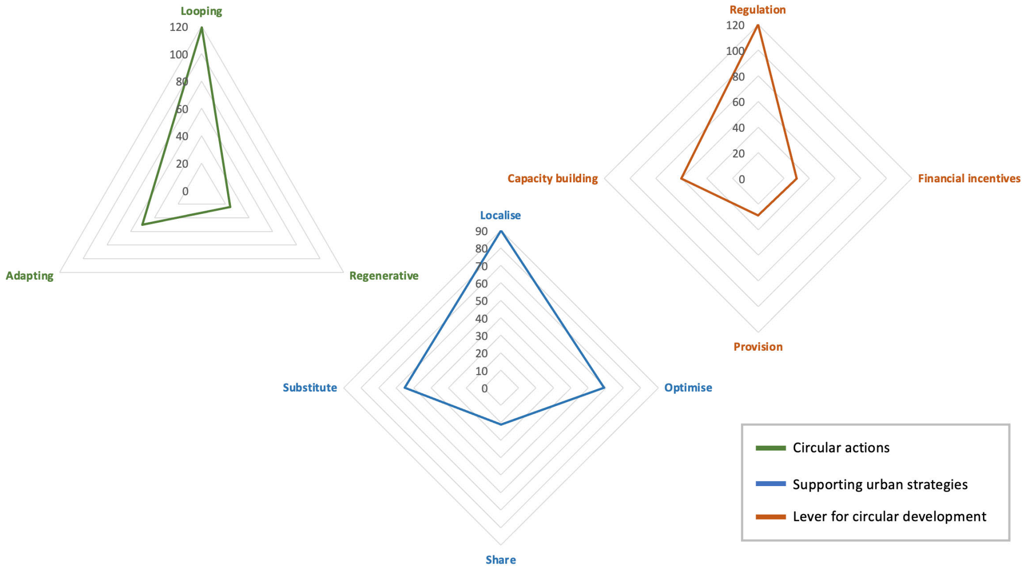

FIG. 3.5 Final selection sorted out in accordance with Williams' (2021) circular city development framework.

TABLE 3.2 Selected articles in relation to looping actions and grouped in themes.

Themes	Publications
Circularity in the built environment	Calvo-Serrano et al. (2020); Densley Tingley et al. (2017); Eray et al. (2019); Foster (2020); Foster and Kreinin (2020); Gallego-Schmid et al. (2020); Geldermans et al. (2019); Giorgi et al. (2020); Huang et al. (2018); Lanau et al. (2019); Ness and Xing (2017b); Poykio et al. (2019); Sierra-Perez et al. (2018); Talamo et al. (2020); Wuyts et al. (2020)
Waste flows management	Ali et al. (2019); Ghaffar et al. (2020); Huang et al. (2018); Khudyakova et al. (2020); Laso et al. (2019); Oncioiu et al. (2020); Ribic et al. (2017); Schneider et al. (2017)
Resource flows quantification and technology	(Albertí et al., 2019; Ali et al., 2019; Arbabi et al., 2020; Bian et al., 2020; Chang et al., 2019; Esmaeilian et al., 2018; Fuldauer et al., 2018; Gassner et al., 2020; Hara et al., 2011; Lanau & Liu, 2020; Lausselet et al., 2020; Lederer et al., 2020; Macintosh et al., 2018; Marcellus-Zamora et al., 2020; Stephan & Athanassiadis, 2017; Sun et al., 2017)
Resource economics	Aceleanu et al. (2019); Burneo et al. (2020); Diddi and Yan (2019); (Kennedy et al., 2016); Laurenti et al. (2018); Lu et al. (2016); Tong and Tao (2016); Veenstra et al. (2010)
Resource governance	Andersson and Stage (2018); Fassio and Minotti (2019); Gravagnuolo et al. (2019b); Kalmykova et al. (2016); Lehmann (2018); Marin and De Meulder (2018); Molina-Prieto et al. (2019); Prendeville et al. (2018); Taelman et al. (2018); Wright et al. (2019)

We also identified a clear tendency to link circularity with recycling as compared to strategies with higher circularity potential. Articles elaborating on looping actions were often focused solely on such actions, while those on ecologically regenerating and adaptation actions normally were paired with others.

Although ecologically regenerating actions were the least covered kind of action, different themes were identified and shown in Table 3.3.

TABLE 3.3 Selected articles in relation to ecologically regenerating actions and grouped in themes.

Themes	Publications
Urban agriculture and food production	Barthel et al. (2019); Corcelli et al. (2019); Dobele and Zvirbule (2020); Fassio and Minotti (2019); Gwynn-Jones et al. (2018); Nadal et al. (2018); Saumel et al. (2019)
(urban) ecosystem regeneration and remediation	Dewick et al. (2019); Macintosh et al. (2018); Miguez et al. (2020); Peng et al. (2017)
Urban ecosystem services provision	Cerreta et al. (2020a); Chowdhury et al. (2020); Stefanakis (2019)

Finally, Table 3.4 shows the identified adaptation actions, which are mostly concerned about (circular) urban adaptation, collaborative governance, capacity building, and knowledge sharing.

TABLE 3.4 Selected articles in relation to ecologically regenerating actions and grouped in themes.

Themes	Publications
(circular) urban adaptation	Cerreta et al. (2020b); Hernández-Hernández et al. (2020); Mazzocchi and Marino (2020); Van den Berghe et al. (2020); Wuyts et al. (2020)
Collaborative governance	Cohen and Munoz (2016); Cuomo et al. (2020); Fabbricatti and Biancamano (2019); Fassio and Minotti (2019); Fleischmann (2019); Lehmann (2018); Petrescu et al. (2016)
Capacity building	Cerreta et al. (2020a); Koop and van Leeuwen (2017); Lu et al. (2016); Obersteg et al. (2019); Ribic et al. (2017); Saumel et al. (2019)
Knowledge sharing	Dabrowski et al. (2019); Izdebska and Knieling (2020)

3.5.3 Policy instruments analysis

Our findings were also analysed in relation to the classification of mainstream policy instruments by Vedung (1998), introduced in section 2.2. Regulations are covered, for instance, by Wuyts et al. (2020) advocating for revising existing norms and standards to transit towards a CBE and the prevention of obsolete stock accumulation in terms of vacant housing in Japan. Looking to improve circular ambitions in port-cities, Van den Berghe et al. (2020) call for revising existing CE ambitions in relation to waste incineration operational capacity of two port-cities (Ghent and Amsterdam) as it may create unsustainable development lock-ins. Romero Perez de Tudela et al. (2020) consider that BE material stocks and flows should be included in strategic planning and management of demolition waste as secondary resource. On shared mobility, Patel and Patel (2020) call for governments to be infrastructural and technological facilitators in the transition towards a public bicycle sharing system in India. Similarly, Lazaroiu et al. (2020) advocate for an active role of governments in regulating green public procurement to lead the CBE transition through the purchasing power of states. Finally, on the integration of anaerobic digesters for food waste in urban environments, Fuldauer et al. (2018) advocate for necessary legal reforms in London to make it possible.

Economic policy instruments are also abundant in our selection. Among the most relevant, Sun et al. (2017) propose both tax exemptions to companies adopting urban industrial symbiosis, and an overall carbon tax to fuel the circular transition in China. It is noteworthy that this is the only reference to the internationally acclaimed carbon tax in our selection. Also, Yang et al. (2019) summarize the importance of carbon emission trading markets and carbon emission reduction targets in China. Tax reform is also suggested for Italy and the Netherlands by Amenta et al. (2019) to incentivize the use of secondary materials and circular labour by decreasing taxes in the construction sector. Giorgi et al. (2020) advocate for economic incentives to promote the design for disassembly and the use of secondary resources in circular building regeneration processes. Economic incentives by governmental investments in infrastructure are also covered for the inclusion of waste pickers in emerging urban CE markets in Ecuador by Burneo et al. (2020). Concerning Waste-to-Energy (WtoE) plants, Gutberlet et al. (2020) suggest disincentivizing their usage by economic means, since WtoE plants show a low degree of circularity as resources are incinerated instead of being mined in landfills in Brazilian and Swedish cities. Nonetheless, WtoE plants are also incentivized in our selection, as it in the case of Thabit et al. (2020) and their research in Jordan wherein WtoE plants are also used to produce clean water. We would also include market formation as an economic policy instrument as for the case of Russia and the extended producer responsibility scheme over the import of tires, documented by Khudyakova et al. (2020), for a market for worn tires is lacking, as tends to be common for secondary resources.

On information instruments, Lanau and Liu (2020) developed an urban resource cadaster to assist urban mining for secondary resources and conclude by incentivizing it usage along supply chains and among stakeholders aiming for component recovery and smart waste management. Awareness campaigns are suggested to improve waste from electrical and electronic equipment (WEEE) in the United Kingdom by Wilkinson and Williams (2020). Free information exchange is claimed as necessary by Yerznkyan and Fontana (2020) to shift the urban water processes towards a circular one. Knowledge transfer and redesign is advocated by Dabrowski et al. (2019) as sine-qua-non action for CE innovation in territories. To make use of urban brownfields for urban ecosystem service provision, Chowdhury et al. (2020) suggest knowledge development and policy guidelines to incentivize different actors at the city level.

3.6 Discussion

3.6.1 Built environment in relation to circular city development

Our results are both expected and unexpected. Firstly, the number of publications that built upon CBE policy instruments is considerable, showing the field is increasing in importance and attention. We also identify the tendency to focus mainly on looping actions in practice is also the case for academic work. Hence, to date, both practically and theoretically it is clear that circular city development is approached mostly through recovery, recycle and reuse actions. This was expected as several authors point out that in CE literature and operationalization the technically driven and arguably 'easy to understand and implement' approaches dominate, instead of more holistic ones (Korhonen et al., 2018b). A marked focus on looping action also makes the work of Williams (2021) crucial: a circular city is not a compilation of flows, value, and supply chains, and thus a circular perspective to urban development is more than simply getting resource flows right. Also expected was the strong predominance of regulation levers for circular city implementation that shows the pre-development stage of most research efforts. In other words, we think this pattern can be associated with contexts wherein drastic changes in cities' ways to deal with their unsustainable BE have been just recently identified, and for which ways forward are proposed and tested. Thus, academic voices point out the need for envisioning new policy perspectives as well as getting rid of institutional barriers and lock-ins to foster such new directions – e.g., Aceleanu et al. (2019), Liu et al. (2019), Pellegrini and Micelli

(2019), Prendeville et al. (2018). Next, it was also expected that optimization and localization as supporting urban strategies were to be abundant in literature, as these two strategies have been widely supported in different circular city and circularity-in-cities frameworks – e.g., EMF (2017b) –, over those of substitution and sharing. Likewise, CE frameworks that do not take spatial scales per se into consideration would still call for closing loops at the local scale, which are normally related to the city level.

The most unexpected result is the limited number of publications that touch upon the three circular actions altogether. For instance, Kennedy et al. (2016) discuss the three circular actions in the context of China's ecological balance with a focus on energy consumption and generation. Yu et al. (2016) do this as well by analysing the Chinese transition of resource-based cities to more sustainable ones. Lehmann (2018) resorts to the Urban Nexus Approach implementation for energy, water, waste, and food streams in Asian countries, and starting from resource-efficiency he proposes measures for regenerative planning and urban resilience. Marin and De Meulder (2018) analyse circular cities representations and transition drivers, making clear that circular cities should embrace more than the mere multiplication of urban circular economies. Nadal et al. (2018) study the feasibility of rooftop agriculture implementation in Spain while highlighting the importance of school community acceptance and infrastructural technical properties. Petit-Boix and Leipold (2018) present a catalogue of city practices towards circularity. According to them, cities are implementing several initiatives that aim to turn them into sustainable circular systems. Whether these initiatives achieve their sustainability goals, however, is unknown. Petit-Boix and Leipold (2018) analyse the extent to which research focuses on quantifying the environmental balance of CE initiatives promoted at the municipal level. Fassio and Minotti (2019) focus on using CE indicators and strategies to shape urban food policies to create a new business and political model towards sustainability in Italy. Their project resulted not only in the collection of food waste and redistribution of food surplus, but also on social inclusion incentives and in the creation of a new systemic governance approaches. A last example is Gravagnuolo et al. (2019b) that aimed to develop an extensive 'screening' of CE actions in emerging circular cities, focusing on eight European historic port cities self-defined as 'circular'. Their results show the existence of an open field of research that is mainly focused on the assessment of circular cities by 'enriched' urban metabolism assessments that could transcend from the accounting of material and energy flows to more economic, social, environmental, and cultural dimensions of circular cities and regions. All the above-mentioned publications show varied circular city policy considerations, yet the total number of publications working with all three circular actions is 13, equivalent to just 7.8% of the total selection. Likewise, and as it can also be seen from the example just presented, most of the publications to some extent consider aspects of the BE into their analysis, but do not put the focus on it.

3.6.2 Policy instruments for a circular built environment in cities

Specifically on policy instruments, we discuss our findings by pointing out the publications' distribution according the four different levers or policy instruments that Williams (2021) has identified in European case studies. Regulation levers, i.e. rules and directives mandating receivers to act in accordance with what is ordered of them, are clearly the predominant ones. This prevalence can be explained by the theory of sustainability transitions, wherein complex transition such as the one of circular cities undergo different phases of development and change to generate radical societal changes (Köhler et al., 2019). The first transition phase is known as pre-development, wherein the status-quo has not visibly changed, yet governmental action is focused on catalysing and directing actors' efforts towards a desired change. Hence, the pre-development phase is characterized by the creation and fostering of visions, the setting-up of spaces for collaboration, and first attempts to norm and incentivize desired changes (Loorbach, 2010; Rotmans et al., 2001).

Something worth noting is that when suggesting policy recommendations, authors seem to shy away from discussion of who should oversee the implementation some of the suggested policy changes. For instance, normally when a material bank or database for material flows and stocks is proposed, it is not clear whether public, private, public-private partnerships or communities should be data keepers and managers –i.e., Marin et al. (2020), Obersteg et al. (2020). This is extremely important as '*discourse on public policy instruments is discourse on power*' (Vedung, 1998, p. 50) and CBE governance is a major aspect of the transition upon which more research is needed (Munaro et al., 2020). Vedung (1998) and Acciai and Capano (2021) also warn that exhaustive typologies for policy instruments are difficult to come up with, which also goes for Verdung's. What is more, policy instruments may fit in all three kind of policy instruments, depending on their verticality, for instance, a mandate for firms to keep databases of their secondary resources may also be a source of information policy instruments for consumers as secondary resources data is public to access.

Considering the circular city development framework proposed by Williams (2021), we find that comprehensive approaches towards CBE implementation in academic work are still lacking. The prevalence of looping actions supports the thesis that CBE and circular city developments have a marked technocratic direction in research (Korhonen et al., 2018b; Wachsmuth, 2012). A more integrative perspective in research will certainly favour more coherent and comprehensive transition policies. As circular actions are partially covered in academic literature, transition policy for CBE implementation may not be well-informed, hence affecting policy coherence towards effective circular city transitions. This is not to say that CBE research has been unfruitful, for it has to date provided promising innovative design standards, technologies, material substitutes and resource data and measurements, among many others (Ness & Xing, 2017b). While CBE research has increased in recent years, its perspectives remain restricted to professionals directly involved in the construction, design, and environmental performance of the BE (Munaro et al., 2020; Pomponi & Moncaster, 2017). What is more, those decision-making spaces where the BE meets the city for the purpose of a circular transition remain under-researched, resulting in unbeneficial reductionism. More holistic frameworks for circular city development are available, for example the Doughnut Economics framework currently being implemented in the city of Amsterdam (Gemeente Amsterdam, 2020). However, the Doughnut was mentioned only once in our selection –by Marin et al. (2020)– for a case study in Belgium, and it is still an infant in the policy process. All the above-mentioned is but a call to increase and spread transdisciplinary actions to embrace complexity instead of trying to reduce it analytically in CBE transitions.

3.6.3 Validity and reliability of the study

It is a scientific imperative to reflect on the validity and reliability of our methods and data. A systematic literature search through keyword-matching strategies in academic databases benefits from the plurality of sources that may or may not end up being part of a final selection. However, it comes at a cost, as it is not always possible to match the selected search strings to all publications touching upon a somewhat specific topic. This is even more difficult when considering emerging fields of studies in which a shared vocabulary is still in the making, such as those of CBE and circular cities. The validity of our method resorts to the ever-increasing use of the PRISMA guidelines for systematic literature search and review in medical sciences and, more recently, in social sciences. The reliability of our data is supported, firstly, by the selection of widely used policy terms such as polic*, manag*, plan*, govern* and lever* as search strings. Secondly, by using two major scientific databases such as Scopus and Web of Science we ensure the inclusion of diverse and indexed sources of information. Finally, the decision to only include open-access publications enables the full reproducibility of our search as well as the revision of our findings. We acknowledge that these decisions also result in the possibility of omitting relevant sources of data, as does our selection of English as the only accepted publication language for inclusion. Finally, we also focused our attention on the relation between cities and BE due to their known global impacts as different knowledge sources point out the transcendental role of cities as driver for planetary system collapse, leaving out the BE resulting in rural settings, yet the implications for rural BE also deserve detailed study.

The implications of our results are important both practically and theoretically. Increasingly, countries and cities have started or are starting to envision their transitions towards CBE as a main way to achieve their circular city policy goal. Whether transition policies are coherent and well-aligned towards achieving BE that contribute to circular city development requires more research. In practical terms, we claim that predominant reductionist and narrow perspectives resorting to mostly looping actions require revision and more transdisciplinary efforts to ensure that also ecologically regenerating and adapting actions should be considered in CBE policymaking and implementation. Yet, the interaction of all three circular actions is something to be analysed case by case, for each city has a unique context characterized by its space, geography, societies and institutions, and systems of provision, among others. The circular city development framework by Williams (2021) allows the analysis of the relation between CBE and policies for its implementation without focusing the analysis on the BE itself but as a distinctive element of part a city. In terms of theory, we claim that according to our results science is not well-informing CBE decision-making process as research efforts tend to focus on looping actions. Yet, it is widely accepted that sustainable and circular cities are those contributing to solve the ecological crisis that they have caused in the past, present and in the future as drastic societal changes are not undertaken (UN, 2020). Specifically, for the BE it is urgent to advance frameworks that comprehensively account for such ecological impacts and that offer systemic approaches to addressing them.

3.7 Conclusion

The tradition of policymaking talks about the creation and operation of policy ‘silver bullets’: solutions that from the beginning are understood as *the* pertinent ideas and effective tricks to change specific contexts; however, too often the outcomes of such policies are ineffective as they do not deal with the dynamism of complex adaptive systems (Colander & Kupers, 2014; Kupers, 2020). A circular city perspective for policy focused on CBE and urban transitions helps research and policymaking in not getting stuck in linear solution to complex phenomenon as the case of cities and their sustainability ambitions. For instance, the focus on mainstream ‘circular’ practices as those mainly related to waste management through the recovery, recycling and/or reuse of material flows is not enabling research and policymaking to transcend from looping actions alone to more integrative approaches wherein ecologically regenerating and adapting ones are also well-covered and included. This systematic literature search and review offers a snapshot to support the need for more coherent and comprehensive ways to come up with more sustainable cities and CBE in specific.

The aim of this systematic literature search was to review and analyse the relation between CBE and policies for its implementation as stated in academic literature. The circular city development framework by Williams (2021) was selected as an analytical framework. The goal was to characterize CBE implementation in terms of circular actions, supporting urban strategies and levers for circular city development. The significance of our findings resides in the usage of a circular city concept to approach CBE transition policy implementation, for it provides a more comprehensive multi-perspective set of circular actions for urban development, wherein the BE is not an isolated phenomenon but a result of the complex adaptive system that builds it up: the city. More specifically, this review sought to contribute an early and concise critique of policy for CBE, while highlighting the need for more coherent and integrative policy decision-making processes.

Summarizing based on our sub-research questions, the three of them have been addressed as follows. Firstly, we identified that 166 publications between 2010 and 2020 elaborate on policy related topic for CBE. This suggests that in a significant, ever-increasing amount of CBE papers, the proposed actions towards a CBE are thus linked somewhat to policy development actions, which we see as a positive aspect for the transition towards a CBE. Secondly, when categorizing these actions, we observed that most of them focus their attention on looping actions, and both ecologically regenerating and adapting actions are not sufficiently covered. Unlike ecologically regenerating and adapting actions, looping ones resort to pre-existing, ongoing transitions in energy and waste management in the last decades in both European and Asian countries, regions the most represented by publications in our sample. This confirms what other authors argued before that CBE and circular city developments have a marked technocratic direction in research. Thirdly after identifying what kind of policy instruments are mentioned or suggested, we found that regulation levers are the most predominant kind in comparison with the other three – financial, provisioning, and capacity building – which we understand as a sign of the immaturity of circular city development approaches and implementation.

We end this article by pointing out different future research directions. Although policy coherence for sustainability transitions has gathered different perspectives in academic work (Huttunen et al., 2014; Kelleher et al., 2019; Nilsson et al., 2012; Rogge & Reichardt, 2016), it has not yet been identified what it means for the purpose of a circular city and built environment transition. 'What is the meaning of policy coherence?', 'How to assess it?' and 'Whether or not it is possible to reach higher levels of coherence in policymaking and implementing processes?' are, to us, research questions that deserve attention and answers. The need for policy coherence and more comprehensive frameworks for its study also talk about the extent to which circular city frameworks include sufficient perspectives to tackle the ecological consequences that their development has caused, as it is clear by now that recovering, recycling, and reusing strategies are already well-advanced but are not sufficient to cope with cities' unsustainable development. Williams (2021) offers one of the first multi-perspective structured attempts to conceptualize circular city development, in opposition to past ones that did not see the city itself as a system that required changes but a mere space where supply and value chains take place. Yet, it would be beneficial to continue exploring possible missing dimensions to circular city development in the future. Finally, we pointed out just by conducting this systematic search and review that CBE research is not informing circular city development practices in a comprehensive manner, therefore it is imperative to study ways to enhance the theoretical contributions of academia in policymaking processes, as in sustainability transitions in which both science and policy are in pre-development phases to foster radical societal changes.

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4 A framework for evaluating circular policy coherence

A case study

Adapted from: Bucci Ancapi, F. (2023) Ex ante analysis of circular built environment policy coherence. *Buildings and Cities,* 4(1), pp. 575-593.

4.1 Introduction

Unsustainable urban development is a major driver of the current socio-ecological crisis (Millennium Ecosystem Assessment, 2005). The making and operation of the built environment (BE) accounts for 40% of global raw material use, contributes between 25-40% of global CO_2 emissions (Pomponi & Moncaster, 2017), and produces 40% of global waste (Ness & Xing, 2017a). Such a critical context has motivated different governments from local to global levels to adopt policies to change current unsustainable urban trends (Paiho et al., 2020).

In this regard, circular city policies are being developed by various governments to tackle unsustainable urban development. A circular city is "*a concept inspired by biological metabolic systems that seeks to apply the principles and strategies of the circular economy (CE) at the different scales of urban functioning*" (Bucci Ancapi et al., 2022a, p. 1). It aims to reduce a city's intake of non-renewable inputs (e.g. energy and materials) and consequently harming outputs (e.g. waste and emissions), thus tackling a linear urban metabolism (i.e. make-use-waste). The BE as a fundamental element of cities is often included as a key supply-chain of intervention

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in European CE policies (e.g. Government of the Netherlands, 2016; Scotland, 2022; Serbia, 2020). Yet urban metabolism studies have been criticised due to their prevailing technocratic thinking, which tends to depict the city as an agglomeration of supply-chains and resource flows as naturally occurring, ignoring human agency and power aspects (Wachsmuth, 2012). CE frameworks for cities have also been criticised as they tend to overlook basic urban elements such as land, and tend to be reductionist by not treating the city as a complex adaptive system, a result of siloed urban interventions (Williams, 2021).

Since European CE policies have been in place for a short while they have yielded limited effects in the very cities they intend to make more sustainable. On the one hand, most national CE policies are to date in early development phases defined by either the absence of policy or recent policy advances (Cramer, 2022). On the other hand, Circular Built Environment (CBE) policy research, although increasing rapidly, is still immature (Bucci Ancapi et al., 2022b; Munaro et al., 2020). Previous research has identified barriers to circularity in infrastructure policy (Coenen et al., 2022), studied a CBE in relation to the so-called policy cycle (Yu et al., 2022), and pointed out that the current state of research in relation to policy instruments for a CBE is not sufficiently informing policy-making (Bucci Ancapi et al., 2022b).

The concept of policy coherence and its analysis deals with consistency in policy-making and implementation. In principle, coherence is part of policy as different policies' objectives share common ideas (May et al., 2006), thus they should in principle cohere. Previous contributions to the journal have shown the benefits of better aligning BE and climate policy (Herbert et al., 2022), urban policy and wellbeing (Chapman & Howden-Chapman, 2021), and urban regeneration and climate change (Song & Müller, 2022) in accelerating local climate actions. Given the early stage of most CBE policies and research, policy coherence may be useful as a tool for ex-ante policy evaluation. Ex-ante evaluation is a broad assessment conducted in the early stages of policy or project development aimed at identifying which possibilities could yield the greatest benefits once implemented, under the premise that the possibility of influencing a process is greater in early phases of decision-making rather than in operational ones (Samset & Christensen, 2017). By now, frameworks have been developed to assess 'the level' of a circular city, though they have not been combined with policy evaluation. For the former, this study referred and built upon the circular city development framework by Williams (2021), for the latter the policy coherence analysis framework by Nilsson et al. (2012) was used. The aim is to combine the two frameworks and test its potential as an ex-ante policy evaluation tool for circular city policies. This leads us to the research question: what is the potential of combining the frameworks of Williams (2021) and Nilsson et al. (2012) for circular city development and policy coherence in informing policy-making and implementation?

To answer this research question, the remainder of this article is as follows. Firstly, the BE is described through the lens of circularity, the potential of policy coherence analysis as an ex-ante policy evaluation tool, and the individual and combined potential of the frameworks for policy coherence analysis and circular city development Secondly, within the methodology section, the analysis approach fora test case, policy documents, and semi-structured interviews are explained. The sustainable campus development at Delft University of Technology (TU Delft) in the Netherlands was selected as a test case and urban development proxy, as it allows the exploration of the different elements of the frameworks. Thirdly, the results are presented in relation to both frameworks, separately. Fourthly, the need for better understanding of circularity in cities and BE policy, the potential of a combined framework for circular city policy coherence, and the validity and reliability of our study are discussed. Finally, conclusions and policy recommendations for CBE policies are provided.

4.2 Theory

4.2.1 The built environment through the lens of circularity

4.2.1.1 Current state of research

CE policy often seeks to intervene in the so-called linear metabolism of cities, which denotes unsustainable urbanisation through the intake of unsustainably-sourced primary resources for the construction of buildings and infrastructure and the subsequent ever-increasing production of waste (Bucci Ancapi et al., 2022a). (Inter)national and local governments have included the BE in their CE policies aiming for a CBE in the coming decades. Generally, in such policies a CBE is fostered by intervening in the supply chains in the construction and renovation processes through the substitution of primary by secondary resources (e.g., sustainably-sourced or recycled materials), by standardising circular practices in the design, construction and deconstruction of buildings and infrastructure, by creating markets for secondary resources, and by creating, gathering, and sharing the necessary knowledge to make a CBE work alongside construction value chains.

CBE research has rapidly increased in the last decade with a growing interest in policy-making. Ness and Xing (2017a) provided the first conceptual model for a resource efficient BE based on CE principles aimed at, among other goals, guiding policy-makers in the CBE transition. Pomponi and Moncaster (2017) proposed a research framework for a CBE, which contains six dimensions including a governmental one. The authors concluded by recommending more in-depth policy research as it was found to be one of the least explored dimensions. Munaro et al. (2020) conducted a Systematic Literature Review (SLR) about CE in the BE. One of the main research gaps they identified is that of 'circular transition' encompassing gaps such as general policies for the rehabilitation and maintenance of materials, products and systems, and policy instruments such as taxation and regulation. A more recent SLR by (Bucci Ancapi et al., 2022b) identified the different policy instruments concerning the implementation of a CBE. Although a wide variety of instruments were listed, the authors concluded that CBE research is not informing policy-making well enough nor facilitating policy coherence.

4.2.1.2 Circular city: more than the sum of flows

Criticism has been raised about the current understanding of circularity for the purpose of urban development. On the one hand, urban metabolism research is critiqued given its limited concern over human agency and power behind resource flows in cities (Wachsmuth, 2012). On the other hand, the early adoption of business-minded CE frameworks for urban development has also been critiqued as they neglect fundamental aspects of cities (Van den Berghe & Vos, 2019; Williams, 2019a, 2019c, 2021).

The conceptual and analytical benefits of urban metabolism in building up circular city and BE theory are well-documented (cf. Ness & Xing, 2017a), and have yielded the possibility to intervene in resource flows used to build up cities in a more resource-efficient and sustainable manner. However, its limited resourcefulness in explaining why resource flows stream the way they do towards, within and out of urban areas has raised questions. Ultimately, urban (re)development is an outcome of power relations (Ness, 2022). The work of Wachsmuth (2012) illustrates the difference between treating cities as places where urban metabolism occurs versus cities as the result of their metabolism. Such a distinction goes back to a more fundamental debate over the city-nature relation. The former develops from the work of Wolman (1965) *Metabolism of Cities* –linked to the development of Industrial Ecology, the view of industrial systems as ecosystems (Williams, 2021)– and the use of material flow analysis to get 'the flows right' in a context of ever-increasing resource exhaustion amidst the 20th century. Thus, a more sustainable metabolism of a city means being aware of and controlling the intake and discharge of resources in and for cities: nature fuels the city. The latter conceptualisation of urban metabolism, Wachsmuth (2012) follows, comes from the development of urban political ecology, a discipline that bridges political ecology and urban geography since the late 20th century. Within it, urban metabolism is linked with the socio-ecological drivers of urban development, framed according to eras of economic paradigms (e.g., industrialisation, post-industrialisation, and globalisation) (cf. Pill, 2021). Urban political ecology problematises resource flows as in the socio-ecological drivers and mechanisms through which they are produced and streamed: the city as a socio-ecological product. Although resource scarcity remains central in the understanding of a city's metabolism, questions concerning who wins and loses in respect to a specific flow is gaining in importance. While the study of urban metabolism has absorbed some of the issues that urban political ecology has shed light on, most of its research trajectory remains mainstreamed to the idea of nature as fuel for cities (Wachsmuth, 2012).

The adoption of business-driven CE frameworks for the development of cities has also been met with critiques. What could be understood as a way to expand a CE to the urban context in early stages of conceptual development is also seen as an over-simplified notion of what a city really is (Williams, 2019a). Williams (2021, p. 11) explains what moving from a CE to a circular city concept entails. A CE focuses on increasing economic efficiency of production systems that results in environmental benefits and its goal is mainly capital and wealth accumulation. Meanwhile, a circular urban system (or circular city) is a spatially-bounded, locally governed system that focuses on systems of provision (i.e., infrastructure and services) instead of systems of production. Williams discusses the RESOLVE framework by the Ellen MacArthur Foundation (2015) to make the distinction between a CE and a circular city. Widely known for its 'butterfly diagram', The RESOLVE framework defines a CE as one that creates value through different mechanisms in technological and biological processes. It includes six actions related to ecological regeneration, closed loops of resources, sharing resources, optimisation and efficiency of products, the dematerialisation of products, and the substitution of linear products. Williams' criticism can be summarised in three main points: (1) RESOLVE does not consider space, as in where those technological and biological processes take place, (2) RESOLVE is blind to land and infrastructure as fundamental components of urban development, (3) RESOLVE does not consider infrastructure in its conceptualisation, a major stock of urban resources. The work of Wachsmuth (2012) and Williams (2019a, 2021) triggers the need to question whether circular city and BE policies are well aligned in bringing them about and whether current policy trajectories encompass the necessary knowledge or content for urban change.

Zooming in from cities to their BE, the BE's relation with policy and circularity has been framed mainly from the perspective of construction management, by considering the BE as a supply- and value-chain from which resource flows need to be turned more circular. As argued by Williams (2019c, 2021) and Bucci Ancapi et al. (2022b) such flow-centred perspectives come at the cost of neglecting the understanding of the BE as a component of the complex adaptive system that creates it: the city. Put another way, the mere juxtaposition of circular flows in cities will not bring about more circular urban metabolism (Wachsmuth, 2012). A BE possesses artefactual complexity as each built element has its place and changes depending on the agency of people through which the city emerges (Marshall, 2012). Hence, the BE is not only an artifact but the enabler of most urban activities and systems of provision.

4.2.2 Policy coherence analysis for circular policy evaluation

4.2.2.1 Policy coherence in a glimpse

Policy coherence is "an attribute of policy that systematically reduces conflicts and promotes synergies between and within different policy areas to achieve the outcomes associated with jointly agreed policy objectives" (Nilsson et al., 2012, p. 396). Greater policy stability and effect is an expected result of increased coherence (May et al., 2006). Research about policy coherence gained traction in the 2000s (e.g., Carbone, 2008; May et al., 2006; Picciotto, 2005), but it was not until 2015 that publications on the topic started to have a sustained increase encompassed in two main groups: governance coherence (related to multi-level policymaking processes) and policy-specific coherence (linked to policy objectives and instruments within a specific policy domain) (Righettini & Lizzi, 2022). According to Nilsson et al. (2012) coherence deals with relationships between policies, which account for interaction within a single policy domain (internal coherence) or between different policy domains (external coherence). Interactions can also be vertical or horizontal, the former referring to policy relationships at the same level of governance, the latter to relationships across different spatial scales of governance. For the sake of coherence analysis, policy domains are divided into goals, instruments, and implementation practices. Although policy coherence analysis has established different research directions and methodological frameworks (cf. Righettini & Lizzi, 2022), according to May et al. (2006, p. 382), it normally faces two complications when assessing policy: (1) system boundaries: identifying the policies that should in principle cohere, and (2) the inability to directly measure the consistency of policies.

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4.2.2.2 Policy coherence as ex-ante policy assessment tool

Given the current state of CE policies for cities and BE in Europe, its prevalent focus on supply- and value-chains instead of urban systems of provision, and the short time most CE policies have been in place for, policy coherence may well serve as a policy evaluation tool. Policy coherence analysis has been used as an *ex-post* evaluation tool (Righettini & Lizzi, 2022), but its use for *ex-ante* policy evaluation has not yet been tested. However, the European Union (EU) acknowledges that greater coherence is an expected output of ex-ante policy evaluation, Although ex-ante evaluation is a EU legal requirement, it is only meant for the appraisal of expenditure programmes (Smismans, 2015). What is more, the link between ex-ante and ex-post evaluation for policy analysis remain under-theorised (Mergaert & Minto, 2015). Left to its own devices, policy coherence analysis can identify possible misalignments looking at what is available: policy documents, their goals, instruments, and implementation practices (*process*-based analysis). If then policy coherence analysis is paired with a circular city framework (*content*-based analysis) it might deliver analytical outcomes that potentially increase the coherence of circular city and BE policies.

Accordingly, his article combines the framework for policy coherence analysis by Nilsson et al. (2012) and the circular city development framework by Williams (2021) (Figure 4.1). The framework by Nilsson et al. (2012) builds on the relationships within and/or between policy domains. The analysis is enabled by an analytical template that considers: (1) the overall assessment of interactions, (2) key synergies and conflicts, (3) opportunities for synergy enhancement and conflict mitigation, and (4) issues and implications. Williams' framework was developed based on the analysis of European case studies. It bounds three circular actions. Circular actions encompass looping ones, related to the so-called 'R-Ladder' (cf. Potting et al., 2017) composed by reuse, recycle, reduce, and other circular strategies. Ecologically-regenerative ones foster the regeneration and support of ecosystem (services) diminished by historical processes of unsustainable urbanisation. Adapting actions in turn seek to improve and support capacity building and adapt to change. Williams' framework has previously been used to analyse the state of research concerning policy instruments for a CBE (Bucci Ancapi et al., 2022b).

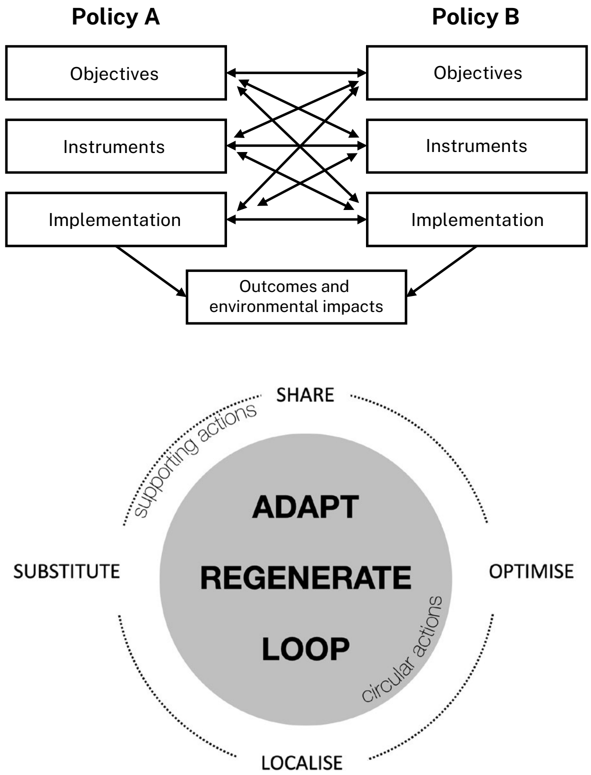

FIG. 4.1 Above: Interacting layers of policy from objectives to implementation (Nilsson et al., 2012). Below: circular city development framework (Williams, 2021)

4.3 Materials and Methods

To explore the analytical potential of both frameworks separately and the usefulness of a combined framework as ex-ante policy evaluation tool, this article uses a qualitative approach based on a test case. Sustainable campus development at TU Delft was selected as a proxy for urban development. The selection of this case follows an information-oriented selection of a critical case (Flyvbjerg, 2006), thus the chosen case is expected to deliver enough information to carry out the analysis. TU Delft as a self-contained, 'touched-by-the-city' campus (den Heijer & Magdaniel, 2018), and public institution offers a concrete opportunity to go from national policy goals to local implementation in a single project. This study focuses on the vertical and internal coherence of BE development, as policy domain within

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TU Delft. The TU Delft campus possess a large spatial scale (6,6% of the total area of the city of Delft) and its development strategy includes the goal of bringing the campus and city closer together (under the concept of 'univercity') (Delft University of Technology, 2021). Nonetheless, the use of this case as a proxy for urban development does not occur without limitations. Urban development occurs at the intersection of different levels of governance and multiple actors (Pill, 2021; van Bueren & de Jong, 2007b; van Bueren & Priemus, 2002), which is not the case for TU Delft as the university owns and operates most if not all of its BE. Yet, the BE of TU Delft must comply with European, national, and local urban and construction policies, and thus the case of TU Delft campus development is suitable to for the purpose of this study.

4.3.1 A sustainable built environment at TU Delft by 2030

The campus of TU Delft has constantly grown and changed during the last century. TU Delft has a long-lasting history of campus-related research (i.e., Den Heijer, 2011; Valks et al., 2021) and recently on its campus circularity and carbon emissions (Herth & Blok, 2022). It is governed autonomously and funded by its own resources and public-private partnerships. It contains faculties and research centres; administrative departments and specialised units for campus and real estate development (Curvelo Magdaniel, 2016; Rymarzak et al., 2020); services such as supermarkets, restaurants, and gyms; housing for students and staff; and, its own energy production facilities and grid.

TU Delft decided in 2018 to become a circular campus by 2030. By adding this goal to its multi-annual plan 2018-2024, the university has taken actions to bring about a more sustainable campus. Most of such changes were recently included in Sustainable TU Delft: Vision, Ambition and Action Plan for a Climate University (2022), a sustainability strategy prepared by a recently appointed Sustainability Coordinator. Out of seven strategic operations within campus, three have a direct impact on the campus' BE: ecocampus, construction & renovation, and energy systems. TU Delft aims to halve its intake of primary resources by 2030, in line with the national ambition of lessening by 50% the intake of primary resources in 2030 and 100% by 2050. These three operations are managed by the Campus Real Estate and Facility Management (CRE&FM) Department. Hence, our test case focuses on the internal coherence of policies developed by and for CRE&FM as well as its vertical relationships from the international to the TU Delft level. In 2022, TU Delft announced a budget of one hundred million euros to make its campus more sustainable (Delft University of Technology, 2022).

The governance of TU Delft sustainable transformation is depicted as a flower, with each unit involved represented as a petal (Figure 4.2), resulting in the convergence of top-down and bottom-up approaches. Top-down actions come from the University's Executive Board (CvB), while the bottom-up ones come from the cooperative efforts of faculties, administrative departments and the broader university community. A core team with one representative from each university unit articulates collective action.

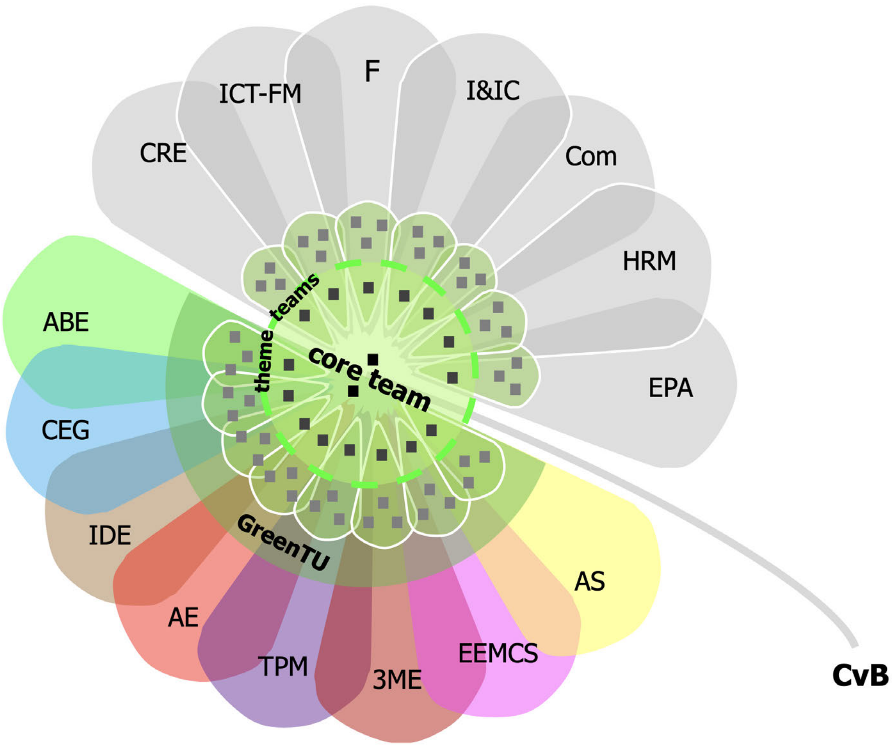

FIG. 4.2 TU Delft 'flower of governance'. The eight petals in the bottom represent faculties, while the seven petals on top represent administrative units. Source: van den Dobbelsteen and van Gameren (2021).

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4.3.2 Sample

Fourteen policy documents specifically referring to CBE were analysed from the European level to that of TU Delft to analyse the relationship between policy goals and instruments (Table 4.1). This decision gives an answer to the question of which policies should in principle cohere (May et al., 2006). The study only includes policy documents with a distinctive consideration of a CBE without considering policy documents that build upon non BE related CE policies nor in relation to waste management frameworks. Except for internal TU Delft documents, all are open access. Policy documents from CRE&FM Department were gathered. Subsequently, semi-structured interviews with the participants were also conducted to analyse the relationship of previously identified policy goals and instrument, and implementation practices.

TABLE 4.1 Selection of documents for analysis, sorted by scale.

Internat.	EU Circular Economy Action Plan (2020)
National	A Circular Economy in the Netherlands by 2050 (2016)
National	Grondstoffenakkord (Raw Materials Agreement) (2017)
National	Transitieagenda Circulaire Bouweconomie (Transition Agenda Circular Building Economy) (2018)
National	Naar een circulaire bouweconomie (Towards a circular building economy) (2019)
Provincial	Circulair Zuid-Holland samen versnellen (2019)
Local	Omgevingsvisie Delft 2040 (2021)
TUD	Strategic Framework 2018-2024 (2018)
TUD	Campus Strategy (web)
TUD	Sustainable TU Delft Vision, ambition and action plan (2022)
TUD	CRE&FM-01 – Vision and Ambition for development, new buildings, and operations (2018)
TUD	CRE&FM-02 – Key Performance Indicators and Criteria for making a sustainable campus (2020)
TUD	CRE&FM-03 – Guidelines for Circular Deconstruction (2021)
TUD	CRE&FM-04 – Deployment of sustainability resources (2021)

The recruitment of participants with specialised knowledge on sustainable campus development was conducted by identifying collaborators of the CRE&FM Department at TU Delft in internal documents and university press. The participants are experts in campus health and wellbeing, innovation on campus, energy systems, ecology on campus, construction and renovation, and from TU Delft sustainability and strategic planning teams. The interviews took place between December 2021 and February 2022 and were conducted online. In total 12 interviews were conducted. They were semi-structured following the factors for policy coherence analysis by Ranabhat et al. (2018), which distinguishes five factors, namely: motivation, measures, implementation plans, resources, and monitoring and evaluation. These factors provide information about implementation practices. Interviews were transcribed, anonymised, and stored in an encrypted file. Although the sample includes the relevant areas of campus development at TU Delft, it is relatively small and therefore a mitigation strategy was required. Besides selecting interviewees with different expertise in the BE, their insights were triangulated across the sample and with other sources. Thus, cross-validation was possible with secondary data, including the above-mentioned 14 analysed documents (Dąbrowski, 2018).

4.3.3 Analysis

The qualitative analysis of both documents and interviews was conducted with Atlas. ti 22. The analysis of policy documents started by gathering them in a single project. As our project resorts to Dutch policy documents, some had to be translated into English. Three rounds of coding followed, starting with open coding as a preliminary attempt to identify information of interest and subsequently by two rounds of theoretical coding so as to identify references to policy levels and circular actions, and factors of policy coherence. In total 11 codes were created and used for this analysis. The data set can be accessed through the 4TU Research Data repository[8]. The interviews were recorded in English with prior informed consent. Additionally, the identification of circular actions in the selected policy documents distinguishes between actions explicitly and implicitly referred to. The analysis of internal and vertical coherence was done using the analytical template of Nilsson et al. (2012). Appendix I includes the inventory of CBE policies for our test case. To know more about the operationalisation of the Circular city policy coherence framework in relation to this case study, see Appendix IV.

8 https://doi.org/10.4121/22250752.v1

4.4 Results

4.4.1 Findings in relation to circular actions

4.4.1.1 Looping actions

In relation to Williams (2021) circular city development framework, policy documents analysis shows a predominant focus on looping actions (Table 4.2).

TABLE 4.2 Circular actions covered in selected policy documents.

Policy documents	Circular Actions		
	L	ER	A
Circular Economy Action Plan (2020)	e		
A Circular Economy in the Netherlands by 2050 (2016)	e	i	e
The Raw Materials Agreement (2017)	e		
Transition Agenda Circular Building Economy (2018)	e		e
Towards a Circular Building Economy (2019)	e		i
Circulair Zuid-Holland samen versnellen (2019)	e		i
Omgevingsvisie Delft 2040 (2021)	e	e	i
TU Delft Strategic Framework 2018-2024 (2018)	e		
Campus Strategy (web)	e		e
Sustainable TU Delft Vision, Ambition and Action Plan (2022)	e	e	e
CRE&FM-01 (2018)	e	e	e
CRE&FM-02 (2020)	e		e
CRE&FM-03 (2021)	e		e
CRE&FM-04 (2021)	e		e

Abbreviations: L: looping, ER: ecologically regenerative, A: adapting, e: explicit reference, i: implicit reference.

In all documents explicit mentions to the R-Ladder were identified. At the university level, policy documents from CRE&FM Department (CRE&FM-01, CRE&FM-02, CRE&FM-03, CRE&FM-04) relate to circularity by defining policy measures such as reduce resource demand, energy efficiency, (locally produced) renewable sources of energy, reuse of energy and material flows, and design flexibility and adaptability of buildings for future needs. CRE&FM-03 establishes six rules for building renovation, namely: (1) sustainability is approached integrally, (2) sustainability is supported by innovative financial models, (3) hierarchy for material selection from avoidance to reuse of existing materials, (4) detachability of building components, (5) waste and transport traffic is avoided in all construction phases, and (6) innovative monitoring and recording methods. Both the Campus Strategy and the TU Delft Strategic Framework, as more generalist documents, only mention a more circular campus as goal. The Sustainable TU Delft Vision, Ambition and Action Plan (2022) summarises most looping actions mentioned earlier in CRE&FM documents and introduces a *New Stepped Strategy* for new buildings design, which "*commences with reducing the demand by passive, smart & bioclimatic design, then the residual streams such as waste heat, wastewater, and waste material are reused and finally renewable sources are used to solve the remaining demand and only clean and nutritious waste is let into nature*" (p. 118). At the local level, the Omgevingsvisie Delft (2021) sets the ambition to improve the circularity of buildings. However, no direct reference to concrete actions was identified. At the regional level, the strategy Circulair Zuid-Holland (2019) seeks to stimulate innovation in construction by supporting research and applications of new materials (e.g., recycled concrete and timber) and flexible building forms (i.e., modular buildings). At the national level, policy measures cascade from A Circular Economy in the Netherlands by 2050 (2016) down to the Raw Materials Agreement (2017), the Transition Agenda Circular Building Economy (2018), and annual implementation plan Towards a Circular Building Economy (2019). Thus, these documents share three main goals set by A Circular Economy in the Netherlands by 2050 (2016), namely: (1) raw materials in existing supply chains must be used in high-quality manner; (2) in case of need for new materials, these must be sustainably produced, renewables, and generally available; and (3) new design and production methods must be organised differently as to promote new ways of consumption. Finally, at the supra-national level, the EU Circular Economy Action Plan (2020) mentions the needs for recycled content requirements in construction projects as well as material recovery targets.

4.4.1.2 Ecologically regenerative actions

Ecologically regenerative actions are the least mentioned ones. Only three documents include explicit references and only one a more implicit one in relation to the BE. At the university level, CRE&FM-01 seeks to create a healthy living environment by considering aspects such as greenery, water, biodiversity, and climate adaptation in the development of new areas and buildings within campus. The Sustainable TU Delft Vision, Ambition and Action Plan (2022) states: "*The university will be a natural, biodiverse, circular, self-sufficient, climate positive campus where people and nature co-exist. The campus will be embedded and connected to the green and blue structures around it.*" (p. 96). This document is the only one to directly link ecosystem (services) and buildings. Hence, greenery is not only to take place in green areas, but also in hard surfaces (e.g., roofs, facades, terraces). The university's botanical garden should be improved to host more biological species. At the local level, Delft's Omgevingsvisie envisions a nature-inclusive city through infrastructural green networks spread throughout neighbourhoods, as well as through buildings that offer ecosystem services provision. Only implicitly A Circular Economy in the Netherlands by 2050 (2016) includes in its vision for 2050 that "*buildings will utilise ecosystem services wherever possible*" (p. 59), yet ecologically regenerative actions are not included in the measures the document sets for circularity in the BE, nor anywhere else in the document.

4.4.1.3 Adapting actions

Adapting actions are explicitly mentioned in eight documents and somewhat implicitly in the other three. At the university level, the TU Delft Strategic Framework (2018) establishes the goal to improve participation by setting up living labs – or local co-creative experimental projects (cf. Kris & Ellen van, 2017)– through which the university's community *"builds up know-how, financial resources and organisational tools for an effective organisation"* (p. 45) CRE&FM-01 states that buildings must take future needs on campus into account in early stages of construction processes given substance to the flexibility and adaptability of buildings. CRE&FM-03 requires innovative monitoring and recording methods in the demolition of buildings to reuse components in new construction projects, thus prioritising the use of locally-sourced resources. CRE-04 includes an integrated approach to a living lab with different TU Delft departments, faculties, and research institutes, to involve them in the building projects. The Sustainable TU Delft Vision, Ambition and Action Plan (2022) introduces a myriad of positive stimuli to influence the university community's behaviour. Living Labs are to be created for the engagement of the university's campus development through workshops, lectures, debates, hackathons, guidelines, and tools. A Circular Economy in the Netherlands by 2050 (2016) mentions city deals and local value chain agreements for a CE by which regional governments, companies and knowledge institutes collaborate in systems of learning, and the construction of indicators for monitoring progress, thus adding additional capacity to local governments. In the Transition Agenda Circular Building Economy (2018) living labs are also included as driver for experimentation, cooperation and knowledge sharing.

4.4.2 Findings in relation to policy coherence

4.4.2.1 Overall policy assessment

Internal coherence in the selected policy documents contributes to synergic interactions. Since circularity became a(n) (inter)national policy goal, it has been operationalised into more strategic objectives and an ever-increasing set of instruments. Given the initial stage of development concerning circularity, most implementation practices have not yet produced visible impacts.

At the European level, the EU Circular Economy Action Plan (2020) includes the BE as a key value chain in the transition towards a more CE. A Circular Economy in the Netherlands by 2050 (2016), the root strategy for all later developments in the country in relation to circularity policy, establishes a common framework to move towards an economy that should reduce their primary resource intake by 50% in 2030 and by 100% in 2050. This national strategy creates the Raw Materials Agreement (2017), which in turns creates the Transition Agenda Circular Building Economy (2018), which is executed annually through an implementation plan: Towards a Circular Building Economy (2019). These policy documents converge in four action lines, namely: market development; measuring, policy, legislation, and regulation; and knowledge and awareness. At regional and local levels, both the Circulair Zuid-Holland samen versnellen (2019) and Omgevingsvisie Delft 2040 (2021) set their circular ambitions in direct relation to the national ones. Although not explicitly, TU Delft policies seem to follow the same national ambitions as they coincide in the timeline for primary resources reduction. The university policy started in 2018 and since then has developed a series of internal actions. CRE&FM Department in four years provided itself with a vision and ambition document on circularity and other sustainability aims, followed by a set of key performance indicators (KPIs), a guideline for circular (de)construction, and a special budget for sustainability.

4.4.2.2 Key synergies and conflicts

At the level of *objectives,* there are no immediate conflicts portraying the BE as a value chain requiring sustainability interventions. The overarching objective to reduce by 50% and 100% the use of primary resources in the Dutch economy is further detailed in objectives that in our selection can be grouped in eight themes, namely (Appendix I): (1) Reduce the intake of primary resources; (2) Substitute unsustainably-sourced resources for sustainable ones; (3) Develop new design and production processes to promote new ways of consumption; (4) Reuse secondary resources; (5) Measurement and reporting; (6) Market development for secondary resources; (7) Policy, legislation, and regulation, and; (8) Knowledge and awareness.

At the level of *instruments*, they are all aligned towards the operationalisation of the goals and themes mentioned above. Thirty-nine tools were identified in the documents. Regulatory instruments cover compulsory material passport and digital logbook use in construction projects, and incorporating circularity into governmental standards for construction. Economic instruments cover circular public procurement including life cycle assessment; subsidies for circular businesses and earning models; incentives for increasing the demand for circular products and services; incentives for R&D, experiments, prototypes, and specific projects; carbon tax; carbon pricing. Information instruments instead cover strategies, agendas, and implementation plans at different governance levels; key performance indicators; guidelines for demolition; sustainable construction certificates; awareness campaigns; and the inclusion of circularity in education. Although all these instruments are included, a few of them have been implemented to date. Most of them relate to information instruments, as they can be created and put to action by existing institutions within their powers. Instruments with more levering power such as regulations and taxes depend on wider, slower political discussions and hence take longer to be implemented.

On *implementation practices*, advances are observed in two distinctive levels: national and TU Delft. National policy implementation is concretised in Towards a Circular Building Economy (2019), which defines four action lines, namely: market development; measuring; policy, legislation, and regulation: and, knowledge and awareness. At the TU Delft level, implementation has gone from the siloed actions of CRE&FM Department to a university-wide, integrative governance process involving all faculties and services on campus. Conflicts were not directly observed, yet considering the existence of other goals such as ecological regeneration and climate neutrality on campus, conflicts may rise when building projects are executed as key performance indicators are available for carbon neutrality (specified in units), while circularity and ecological regeneration do not have a set of indicators.

4.4.2.3 Factors of policy coherence

Motivation

Sustainability experts at TU Delft pointed out how motivation comes from a slow but constant process of awareness that first started with particular researchers, staff members or grassroot movements within the university. Compared to previous policy goals resulting from national policies they had to comply with, circularity –in the absence of legal standards for circularity– was initially driven and taken up by enthusiasts.

"People are switching and also looking at their own behaviour and that of their own work. The university is really, really working on becoming sustainable and it comes from a lot of people from within and not because they have to." Interviewee 10

Measures

Our interviewees had a somewhat comprehensive understanding of the goals and measures to be taken on campus. Most of them made reference to internal CRE&FM circularity goals or to the overall university goals to become circular by 2030. Responses reveal that people have been hired for sustainability purposes on campus. Next to the measures described in section 4.1. and 4.2, given the context of the pandemic new studies and measures are being carried out. Worth noting is the new pilots on hybrids ways of working, which have the potential to optimise the use of office spaces and reduce the demand for new buildings.

"Yes (I am aware). Because I was attracted to help reach those goals for the development on the South campus in at the Kluyver area." Interviewee 9

"So there are different perspectives in that hybrid way of working. They're testing it now because they don't want to roll it out for the whole campus for a lot of money, and then maybe the situation is changing and we have to build it back (…) It's also dependent, of course, of the development in the COVID situation." Interviewee 8

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Implementation plan

Two central roles were highlighted by the interviewees in relation to sustainability actions specifically, the appointment of a sustainability coordinator at the university level and that of a sustainability programme manager at CRE&FM, both of whom have structured the different circular actions in relation to campus goals. The development of key performance indicators was also pointed out as a key element to implement actions as they provide a sense of direction in implementation.

"It has absolutely changed. Then I don't know how long the sustainability program manager has been in his position, but I think that's new or relatively new on the campus. I think if you look at the whole sustainability team, we have all these people thinking about how can we speed up the thinking and the visibility of everything that is sustainability on campus, et cetera. Interviewee 11

"So one big thing that the sustainability team has been working on is to identify and get sign of KPI's (key performance indicators) for sustainability and projects assessment. (...) If things don't come down to KPIs, then they weren't really, you know, be measurable, so the one is a hard outcome of driving towards actual KPI's for sustainability." Interviewee 2

"the atmosphere that has changed and it's within the last year. 'Cause when I talked about other kinds of trees or more flowers make it visible. (...) But one and a half year ago they would hold me for a tree hugger, then all of a sudden I hear other people explaining my ideas to me!". Interviewee 7

Resources

Resources, both economic and human, have increased recently in relation to the sustainability goals. Interviewees agree that resources have been made more available and strictly aimed at circularity. Yet, as sustainability awareness has increased, also have increased the tasks to meet the increasing number of goals.

"If you would put the amount of attention that goes through sustainability in full time equivalence in CRE&FM, it's definitely gone up over the years. Not only from people who were working on it full time, but also if you look at attention paid by project managers, developers, people from the maintenance department." Interviewee 1

"We know that we got 100 million euros or something, but it is not yet allocated in the campus strategy, so we don't have euros yet. (...) We see we don't have enough people for the job. I'm working to fill in the vacancy. We are 11 people, next year we will have 13." Interviewee 4

"For us there are more people and money is put into sustainability, in the transition, yes, but there's more willingness to invest in sustainability and also for a budget but also with people. But I think it still isn't enough. Interviewee 5

Monitoring & evaluation

The new sustainability goals require more and new sets of data. Compared to other goals such as carbon neutrality, for which KPIs and standards are available nationally, circularity and ecological regeneration are not as advanced. New ways of reporting are in the making, but at the same time some professionals do not consider them relevant in fulfilling their tasks.

"We should have a, uh, let's say quarterly report on our project portfolio. (...) So what's the combined effect of the interventions that you're going to do and what's the status in each project. Uh, and the second one is for like, I think regular reports on your existing buildings and those are made less frequent. Interviewee 1

"Not yet, not yet. We are working on it with the sustainability team. Co-reporting, etc. And then we have to do monitoring. That's also very interesting. Resources monitoring. The request of data increased a lot." Interviewee 4

"So basically the ecocampus vision was kind of trial and error way, working towards a known set of KPI's which we haven't developed yet ourselves but we have a pretty clear picture of where we would like to go if we would have to do it." Interviewee 6

"No, no. There are goals and I'm free how to implement those goals (...) there are no guidelines." Interviewee 7

4.5 Discussion

4.5.1 Not see the city for the buildings

While all circular actions were identified in our analysis, to a certain extent, the predominance of looping ones and the noticeable lack of ecologically regenerative ones echoes previous findings about the manner in which the BE is currently treated in CE policy, this is framed as a matter of CE in supply chains instead of circular systems of urban provision (cf. Bucci Ancapi et al., 2022b; Williams, 2019a, 2019c; Williams, 2021). What has been characterised as a marked technocratic direction in circular city and BE research (Bucci Ancapi et al., 2022b; Korhonen et al., 2018b; Wachsmuth, 2012), was also identified in circularity as policy domain in our analysis. The limited concern over land and infrastructure in CBE policy as consequence of picking a CE approach over a circular city one was also confirmed (Williams, 2019a, 2021). In the case of TU Delft's campus development, the situation is depicted in Table 4.2. Looping actions, such as the reuse of secondary resources from demolition or requirements for recycling targets in construction projects, appear to be well-equipped by adapting measures such as city deals and living labs, as co-creation mechanisms in decision-making at most governance levels. Nonetheless, the sourcing and availability of secondary resources to fuel a CBE remain covered enough in policy documents, which is elemental for a CE to function (Andersen et al., 2020). On the contrary, ecologically regenerative actions are barely mentioned at the (inter)national level, which is portrayed by the inclusion of ecosystem services (such as green facades and roofs) as part of the vision of A Circular Economy in the Netherlands by 2050 (2016), but without reference to a specific goal or instrument. This may explain why this intention vanishes as the national circular ambition becomes sectoral policy actions. Thus, at the (inter)national level policies tend do not see the city for the (circular) buildings. Ecologically regenerative actions receive more detailed attention at the regional and TU Delft levels through the inclusion of, for instance, blue and green infrastructure and ecosystem services provision in buildings' facades and roofs. The University's new governance approach offers a more integrative pathway to accomplish its sustainability goals and preventing otherwise siloed CBE developments. From all the analysed policy documents, the Sustainable TU Delft Vision, Ambition and Action Plan happens to be the most comprehensive one in terms of the inclusion of circular actions.

In relation to policy coherence, noticeable is the development of a well-aligned and increasing set of goals and instruments within circularity as policy domain in the Netherlands. This coincides with earlier findings that assessed the circular transition in the Netherlands as one close to an acceleration phase (Cramer, 2022). The eight kinds of objectives included in Appendix I use thirty-nine instruments including new regulations and standards, economic stimuli such as subsidies and taxes, and guidelines and data requirements. These instruments not only seek to enable looping actions in construction but the subjacent need for change, such as market development, public procurement as driver for concrete demand, awareness campaigns and education, and research and innovation. To date, most implemented instruments correspond to guidelines, roadmaps, and strategies –or so-called information instruments (Vedung, 1998). This became evident through the interviews. While other sustainability goals such as the energy transition are well-equipped with a defined and measurable set of requirements coming from regulations; circularity is not yet quantified with concrete verifiable units as proposed regulations and standards are still to be established, thus making it difficult to monitor in local projects. Such a context of under-developed set of instruments can generate uncertainties in implementation practices. At the TU Delft level, an increasing, more comprehensive set of goals, instruments, and implementation practices have been set up recently. From departmental policies in relation to circularity in construction, TU Delft has established a university-wide sustainability governance approach. Nonetheless, as implementation practices are carried out, the need for further vertical alignment becomes evident as many instruments require (inter)national decision- and policy-making.

4.5.2 The potential of a combined framework for circular city policy coherence

The benefits of combining a content-based framework and a process-based one reside in highlighting and covering analytical blind spots. Their combined results are beneficial both for the study of policy coherence in general and the study of circular city policy coherence in particular. For policy coherence in general, it helps in setting system boundaries for analysis, an acknowledged limitation of policy coherence concerning *what* policies should in principle cohere (May et al., 2006). This also helps in enlarging policy coherence in the case of circular cities and the BE from a purely process-based approached to one that is also content-specific. For circular city policy coherence, this combination of frameworks helps in overcoming the pitfalls of ill-informed transition policy for CBE implementation (Bucci Ancapi et al., 2022b).

Policy coherence analysis has the potential to become an ex-ante policy evaluation tool. It could help early policy-making processes so they don't miss more integrative opportunities, for instance, in pairing looping actions with ecologically regenerative ones for the sake of circular city development and a nature-inclusive BE. Likewise, different communities can benefit from this framework. Circular city researchers gain an analytical lens to understand the governance of circular urban system. Evaluators can advance towards more comprehensive KPIs and assessment frameworks for circular city development. Campus and city staff may use the framework either in early phases of planning or in mid-term evaluation processes to set the course straight and yield more effective CBE changes. Circular city practitioners will get a good idea about the progress of policy goals, what is the current status of policy instruments and common issues in implementation. Policy-makers may use this framework to produce more ambitious and evenly developed policy frameworks that consider all three circular actions, and the factors of policy coherence can provide justification needed to improve current policy goals and instruments or propose new ones. Figure 4.3 shows the combined framework for circular city policy coherence. Further research is required to overcome the limitations of this study, which we discuss in the next section.

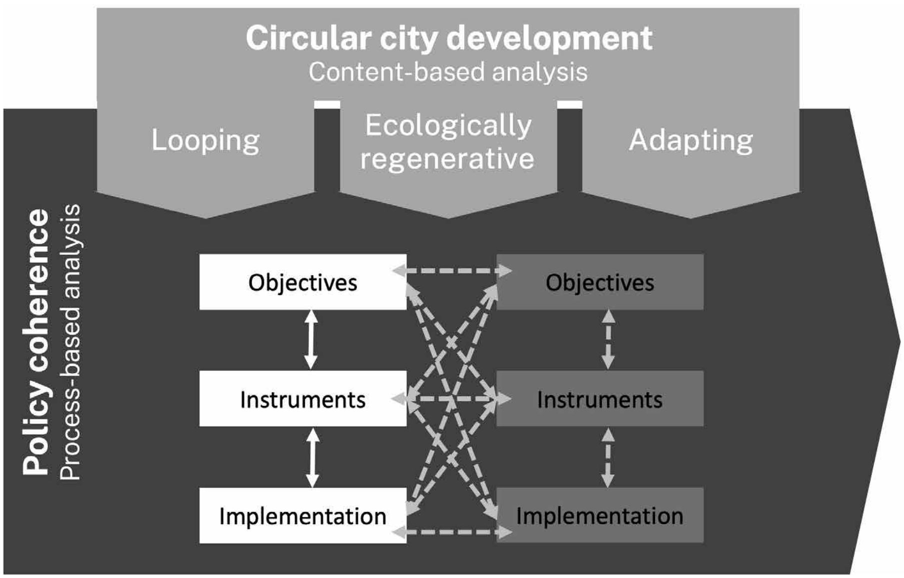

FIG. 4.3 Figure 4.3. Framework for circular city policy coherence

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4.5.3 Research validity and reliability of the study

This study faced several limitations. Firstly, we resorted only to explicit CE policy documents not considering, for instance, the existing policy framework for waste management in a broader sense. Yet this decision was made to highlight the current state of circularity-specific policy development. Secondly, from all possible policy interactions (i.e., internal/external, vertical/horizontal) we only considered internal and vertical ones. We expect more insightful analysis outputs from linking circularity to policy domains such as construction, urban development or spatial planning in general. Thirdly, our results back the selection of TU Delft as an information-driven test case for framework exploration (Flyvbjerg, 2006). However, for this research campus development at TU Delft was considered only as a proxy for local urban development. The application of the framework to a city will most likely unveil new policy interactions and the relation to politics and power relations between the different actors and multi-levels of urban governance that participate in urban development processes. For instance, although we theoretically criticised the limited treatment of issues concerning land and infrastructure in CE policies applied to cities, we did not cover those possible interactions in the analysis. Fourthly, the data extracted from semi-structured interviews by no means provide an exhaustive account of the internal measures TU Delft has taken and continues to take. The interviews were excluded from the policy coherence analysis and used only for examining factors influencing coherence. This approach ensured a focus on the (mis)alignment and synergies of policy objectives and instruments in official documents while enhancing the replicability of findings. Nonetheless, once linked to the factors of policy coherence, the interviews achieve a more detailed account of implementation practices.

The implications of our results are important both theoretically and practically. Theoretically, our results highlight the benefit of better contextualised policy analysis in relation to policy goals that have not been adequately conceptualised or framed. Thus, the analysis of policy coherence is improved by defining system boundaries resorting to scientifically-based frameworks, such as the one developed by Williams (2019a, 2021). Practically, as many governments around the world have started envisioning a CBE, the need to evaluate policies developed for such purpose make this kind of academic exploration relevant and urgent. The current socio-ecological crisis requires thorough and comprehensive policy responses that avoid treating complex phenomena such as cities (Portugali et al., 2012; Williams, 2019a) through siloed policy interventions. Governments at different levels as well as other actors envisioning a more CBE (see Section 6.2) can use the circular city policy coherence framework as a preliminary checklist for the evaluation future urban (re) development projects.

4.6 Conclusion

The aim of this project was to explore the analytical potential of both policy coherence and circular city development frameworks separately and the usefulness of a combined framework as an ex-ante policy evaluation tool. The significance of our findings resides in identifying policy gaps that otherwise would have gone unnoticed given the analytical blind spots of both frameworks used separately. Thus, the combined framework is beneficial for CBE policy-making in relation to urban development. This research provides new explorations of research gaps identified in CBE research in recent years in relation to the governance and policy development of circular transitions in the BE (Munaro et al., 2020; Pomponi & Moncaster, 2017), and more specifically the calls for "*more coherent and integrative policy decision-making processes*" (Bucci Ancapi et al., 2022b, p. 9). To date, the selection of CBE policies from the European to the campus level of TU Delft seems well-aligned in promoting looping actions but less so in supporting circular urban development. In general, the under-developed policy instruments in (inter)national regulatory frameworks leave innovative local experiments, such as the TU Delft campus development, to its own devices meanwhile the university waits for clear rules and guidelines for the application of circular strategies. Echoing Song and Müller (2022), it is an imperative to increase the readiness of higher level authorities to learn from innovative local experiments and to produce flexible regulatory frameworks. Including this framework as a coherence check-list in BE and urban development can better inform circular city policy and improve readiness in early phases of policy-making processes or prior to begin a new policy cycle.

Further research using Dutch cities as objects of analysis can improve the validity and support the generalisation of the findings. Circular city policy coherence will also benefit from the study of other cities and countries where circular ambitions are considered for the BE. The expansion of this framework to other aspects of city development, such as urban food production or mobility, will undoubtedly yield greater policy interactions. The overall governance of circular cities and BE would also benefit from a deeper understanding and testing of policy instruments that wait for development such as (updated) regulations, standards, and indicators (Paiho et al., 2020), and economic stimuli including subsidies and taxes, as existing policy instruments may not bring about a more circular city and BE. We encourage future research to explore new directions to produce sufficient instruments for the radical societal changes they intend to trigger.

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5 Circular city policy coherence in Greater London

Adapted from: Bucci Ancapi, F., Van den Berghe, K., van Bueren, E. (2024) Circular city policy coherence in Greater London. *Cities,* 155(105423), pp. 1-10.

5.1 Introduction

Circular economy policies have been adopted in various cities in Europe as a response to the ever-increasing pressure on natural resources needed for infrastructure and housing (OECD, 2020). The increasing pressure on natural resources comes firstly from the quantitative growth of the built environment and thus the increasing demand for natural resources (e.g. urbanisation), and secondly from the take-make-waste treatment of these resources. This 'linear economy' of resource use undermines the availability of resources needed to sustain urban activities (Paiho et al., 2020; Williams, 2019, 2021). A circular economy has been proposed to reduce the use of unsustainably sourced primary resources through the use of secondary resources, thereby reducing negative environmental impacts (i.e. waste and emissions) (Korhonen et al., 2018).

Current circular economy policies in the built environment have been both praised and criticised. On the one hand, the inclusion of circular economy principles in construction has led to the inclusion of new dimensions of green, energy-efficient, and zero-emission construction, with a particular focus on the environmental and technological dimensions of construction. While 'sustainable building' already included economic and societal dimensions, 'circular building' adds the importance of governmental and behavioural dimensions of building (Pomponi & Moncaster, 2017).

On the other hand, the main critique about current circular economy policies in the built environment concerns the lack of clear definition for a circular built environment –or circular cities (Bucci Ancapi et al., 2022a; Williams, 2019).

A circular city and a circular economy differ in that the former is a locally governed system that is spatially bounded and focuses on enabling systems of provision (e.g., infrastructure and services), while the latter aims to increase the efficiency of production systems and reduce environmental impacts (Van den Berghe & Verhagen, 2021; Van den Berghe & Vos, 2019). In many cases, the (implicit) main goal of a circular economy is the sustainable accumulation of capital and wealth (Savini, 2023; Williams, 2020, 2021). In practice, the lack of a circular city definition hinders the implementation of policies that contribute to a circular city. For example, research in Melbourne (Australia) and Malmö (Sweden) warns that the potential misinterpretation of the circular economy can offset the impact of circular actions in urban strategic planning (cf. Bolger & Doyon, 2019). Research in the Netherlands has shown that circular built environment policies seem well-aligned in fostering a circular economy but less so to create a more circular city, as circular action focus mainly on resource looping (e.g. reuse and recycling) with limited attention to ecological regeneration and adaptation of physical and social fabrics (Bucci Ancapi, 2023), which are also essential parts of circular cities (Williams, 2021). In synthesis, the way policy issues are defined determines the subsequent choice for and coherence of instruments and implementation actions to address the issue at hand (Howlett et al., 2020).

In this article we therefore focus on the (mis)alignment and possible synergies between policy objectives, instruments, and implementation, or, in other words, the policy coherence (May et al., 2006; Nilsson et al., 2012). It is worth noting that the study of coherence does not come without limitations and criticisms. Theoretically, the most fundamental limitation in the study of policy coherence is the definition of system boundaries in relation to the policies that should cohere (cf. May et al., 2006). Empirically, research has shown that more coherent policymaking does not always help to improve the overall policy outcomes, such as reducing inequality (cf. Browne et al., 2023). Yet, these constraints do not diminish the usefulness of policy coherence analysis in informing policy- and decision-making processes (Bucci Ancapi, 2023; Nilsson et al., 2012).

As a metropolitan area, Greater London faces common governance issues related to its scale. As pointed out by da Cruz et al. (2020), the metropolitan scale typically lacks information on its governance and the disconnect between social and political institutions and the socio-technical systems in most metropolitan areas poses a challenge to the effective management of these areas. The study of circular economy governance in metropolitan areas has only recently gained attention as a research topic. The Greater London Authority (GLA) presents an interesting case to examining policy coherence of circular built environment policies due to its authority, governance structure, scale, and the notable gap in governance research that has not been fully explored (Bucci Ancapi et al., 2022b; Heurkens & Dabrowski, 2021; Munaro et al., 2020; Pomponi & Moncaster, 2017).

The Greater London Authority (GLA) has recently set out its own circular economy policy trajectory. A circular built environment is one of the focus areas for the circular economy in Greater London. The circular built environment policy introduces circular methods of construction (e.g. modularity and design for disassembly) and building use (e.g. space sharing and building reuse) (London Waste and Recycling Board, 2015). More recently, the GLA has also included circular economy objectives in the London Plan (2021), the spatial development strategy for Greater London. Policy SI 7, a sub-chapter dedicated to sustainable infrastructure of the London Plan, created the Circular Economy Statement Guidance (2022a), a tool for applying and reporting of circular economy principles in the design, construction, and end-of-life phases of major construction developments in London. By treating building materials as future secondary resources, reducing emissions from the extraction and production of primary resources, London also expects to address the climate emergency.

The GLA has statutory responsibilities for planning, economic development, and the environment in Greater London. It is also an autonomous but still intermediary government layer of government between local and the national government, which allows for analysis of the complexity and layering of policies that impact on Greater London. Moreover, Greater London has been implementing circular economy policy for over a decade. While aspects of the circular economy in Greater London have been studied in terms of local planning practices (Turcu & Gillie, 2020), urban regeneration (Domenech & Borrion, 2022), and circular urban development (Williams, 2020), the issue of policy coherence has not. Therefore, the outcome of circular economy policies in relation to urban development in London remains unassessed. This context leads to the research question: How coherent are circular built environment policies in Greater London?

The main objective of this article is to explore policy coherence analysis in the formulation of circular city policies by looking at specific mechanisms at work. Looking at London's built environment allows for an initial exploration of the overall (mis) alignment and synergies of circular economy policies. Considering environmental and planning plans as policy domains, this article uses the circular city policy coherence framework by Bucci Ancapi (2023) to identify *ex ante* possible (mis)alignments and to enable synergies in the implementation of circular built environment policies in London.

The paper is structured as follows. Section 2 introduces the circular city policy coherence framework, conceptually and how it can be used analytically. Section 3 then explains the methodology and presents the case study. The results are presented in section 4, followed by a discussion of policy (mis)alignment and possible synergies, as well as the validity and reliability of this study in section 5. Finally, section 6 presents conclusions and policy recommendations for circular built environment policy coherence in cities.

5.2 Background

Globally, the construction industry is the largest consumer of resources and raw materials across of all sectors. It consumes 40% of materials and is responsible for 33% of emissions and 40% of waste worldwide. A staggering 42.4 billion tonnes are used to build and maintain houses, offices, roads, and other essential infrastructure (Ness, 2019). These figures are expected to increase given the ongoing shift towards urban living, with 60% of the world's population expected to live in cities by 2030. Although cities occupy less than 3% of the world's land surface, they concentrate 78% of carbon emissions and 60% of residual waste (Grimm et al., 2008). The sustainability of the urban built environment has become a policy concern for governments at various levels, from the international to the local level (United Nations Environmental Programme, 2022). Cities have adopted circular economy policies over the last decade to address, among other things, the unsustainable production and operation of their built environment. In Europe alone, at least dozens of cities have adopted circular built environment policies over this time (European Union, 2023). The construction industry is of particular interest for circularity, as the built environment is strikingly intertwined with the spatial concerns of sustainable urbanisation; arguably, the output of the construction sector is where it would be most desirable for circular economy and circular city ideas to be in sync.

The circular economy is a sustainable development initiative encompassing a shift from a linear production-consumption system to one that applies material cycles and cascading energy flows (Korhonen et al., 2018). While commonly discussed among experts and professionals, the idea of a circular economy is still under debate. As noted by Kirchherr et al. (2023), this debate persists for several reasons, including different interpretations of the concept as it evolves, the greater emphasis on conceptual framing in scientific circles compared to practical implementation, and questions about how (or whether) circularity can effectively balance environmental goals with economic growth. In absence of a “final definition” as Kirchherr et al. (2023) mention, a circular built environment might be better characterised through the practical interventions it involves. These include substituting primary resources with secondary ones (such as sustainably sourced or recycled materials) within supply chains during construction and renovation processes, standardisation in the design, construction, and deconstruction of buildings and infrastructure (for example, designing for disassembly and reuse), the creation of markets for secondary resources (achieved through the development of norms and standards for secondary use); and the gathering and sharing of the necessary knowledge to ensure the successful integration of a circular economy within construction value chains (Bucci Ancapi, 2023).

5.2.1 Circular built environment policy in Greater London

The GLA was established by the Greater London Authority Act of 1999 to act as the elected government for the 32 boroughs of Greater London. Its main aim is to promote the social, economic, and environmental development of the metropolitan area. The GLA is made up of the Mayor of London and the London Assembly and has limited powers over transport, housing, planning, the environment, policing, economic development, and fire and rescue. The GLA differs from a local authority in several legal ways. For example, local authority mayors must form a cabinet from the council and have their budget approved by the council, with decisions subject to scrutiny by the council. These requirements do not apply to the GLA. What’s more, unlike upper tier local authorities such as county councils, the GLA has no responsibility for service delivery. Instead, this role falls to the London boroughs, which are unitary local authorities. (Sandford, 2022).The Greater London Authority Act of 2007 gave the elected government new powers and responsibilities, including a provision to ensure that GLA decisions do not contribute to climate change or its consequences in the city.

The circular economy in Greater London has been proposed as a solution to longstanding problems of waste generation and a housing crisis that requires a million new homes by 2041. When the GLA decided to develop a circular economy policy in 2017, the total amount of waste collected was 3.7 Mton. In that year 12.5% of waste was landfilled, 52.9% was incinerated with energy recovery, 0.7% was incinerated without energy recovery, and 30.1% of household waste was recycled (Greater London Authority, 2022c). Given the projected population growth in Greater London, local authorities would need to collect an additional 1 Mton of waste each year (Williams, 2021) and build approximately 43,000 new homes per year by 2041 (Greater London Authority, 2023).

In 2016, the Mayor of London commissioned ReLondon (formerly the London Waste & Recycling Board –LWARB) to produce a circular economy route map to 2036 (ReLondon, 2023). The Board of ReLondon is made up of: the Mayor or his deputy, who chairs the Board; an additional member appointed by the Mayor; four members elected by London's boroughs; and two independent members appointed by London Councils (ReLondon, 2024). The process was preceded by LWARB's 2015 report Towards a Circular Economy (London Waste and Recycling Board, 2015) (Figure 5.1). The report was aimed to inform, raise awareness, and engage public and private stakeholders in the circular economy. It included the built environment, as one of its focus areas, and listed possible interventions in modular construction, more effective use of buildings, design for building disassembly, and material management and reuse (London Waste and Recycling Board, 2015).

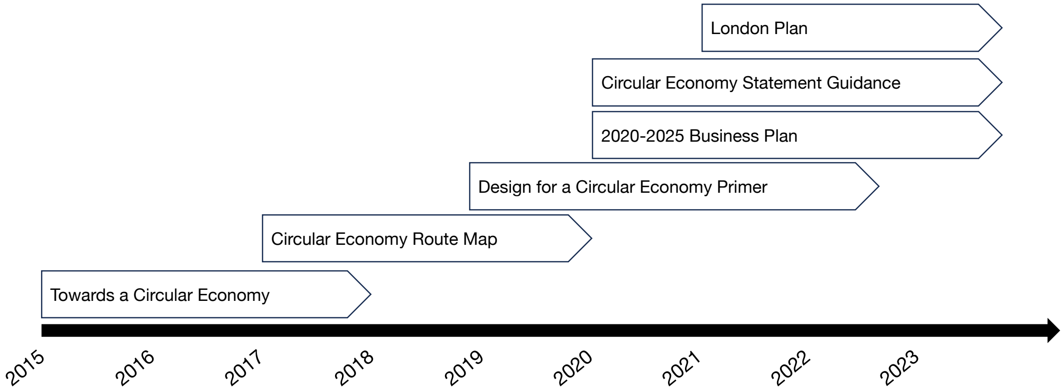

FIG. 5.1 Circular economy policy development in London. Source: the authors.

The 2017 Circular Economy Route Map states that a circular economy approach to the built environment could help deliver more efficient and sustainable homes, business premises and infrastructure (London Waste and Recycling Board, 2017). The chapter on the built environment was influenced by the work of Cheshire (2016), Building Revolutions: Applying the Circular Economy to the Built Environment. The Route Map included a series of actions to accelerate the transition to a circular built environment, namely: (1) design for circularity, (2) management of building materials, and (3) circular operation of buildings. Each one of these actions was accompanied by a list of resources required and expected outputs, outcomes, and impacts.

In 2020, the Route Map was accompanied by the 2020-2025 Business Plan. LWARB is legally required to produce an annual budget for its operations. The Business Plan aimed to support the implementation of London's consumption-based emissions reductions. For the built environment it was estimated that 12 Mton of materials were used between 2001 and 2016, generating 9 Mton of waste: 77% of all waste generated in Greater London. The Business Plan included a financial plan of £6.3m in 2020, which would gradually decrease to £2.7m as upfront investment expenditure would decrease from £2.4m in 2020 to £200,000 in 2025. These resources should be deployed across two programmes: Resource London and Circular London. The former aimed to reduce the amount of waste generated in Greater London and the latter to incentivise businesses to adopt circular economy principles. Both programmes included activities and projects in the areas of advice, support, research and innovation, behaviour change, and capacity building and skill development (London Waste and Recycling Board, 2020). Up to 2024, ReLondon has supported more than 40 pilots and collaborative projects with local authorities, architects, universities and businesses, more than a hundred businesses have received support from the programmes to adopt and scale circular business models and more than 200 local jobs have been created in the circular economy (ReLondon, 2024).

The 2021 London Plan, the spatial development strategy for Greater London, marked the introduction of the circular economy into urban development. The integration of the circular economy into London's built environment was commissioned to the Good Growth by Design programme for a better city through a high quality and inclusive built environment (Greater London Authority, 2022b). Its core concepts are outlined in the Design for a Circular Economy Primer (Greater London Authority, 2019). The circular economy is embedded in five out of twelve chapters, namely: (1) good growth, (3) design, (6) economy, (9) sustainable infrastructure, and (11) funding. Most of measures relating to a circular built environment are included in Chapter 9 under Policy SI 7 - Reducing waste and supporting the circular economy. Policy S7 has three objectives: (1) to promote resource conservation, waste reduction, material reuse and recycling; (2) to implement a Circular Economy Statement to demonstrate the circular economy principles throughout the lifecycle of project development, and (3) to apply the circular economy principles in development plans (Greater London Authority, 2021).

The 2022 Circular Economy Statement was the most recent policy development on a circular built environment in London during the period examined for this article. It is a policy instrument that sets out how a development will integrate circular economy measures into its design, construction, and operation process, including public spaces and supporting infrastructure. The Statement is mandatory for all developments overseen by the Greater London Authority (e.g., those with 150 or more residential units, or over 100,000m2 in the city, 20,000m2 in central areas or 15,000m2 in outer London). In order to comply with this instrument, the Greater London Authority has published a guidance document (Greater London Authority, 2022a). The London Plan and the Circular Economy Statement it contains are the only policy documents subject to public consultation, which took place in 2018.

Williams (2021) points out that circular economy policies are not explicitly included in any policy at the national level in the UK, but are present to some extent in the 2017 National Industrial Strategy in relation to resource efficiency along supply chains, waste management, and economic savings. A prevailing laissez-faire approach has resulted in a fragmented picture for the implementation of a circular economy. The focus of the circular economy in the UK is essentially sectoral, with no consideration of spatial development. Williams (2021) concludes by claiming that the role of cities in the transition to a circular economy is not clear, which may be related to the lack of government agencies responsible for urban development. Greater London is the only urban agglomeration in England to produce a spatial strategy outside of statuary responsibilities, the London Plan (Turcu & Gillie, 2020), which from 2021 includes circular economy provisions mainly related to looping and adaption measures (Williams, 2021). At the local government level, only eight out of 32 boroughs have included circular economy in their policies within the period studied, and only two (Islington and Merton) have included measures in the built environment (Turcu & Gillie, 2020).

5.3 Materials and methods

To analyse policy coherence in circular built environment policy in Greater London this article draws on the circular city policy coherence framework of Bucci Ancapi (2023) (Figure 5.2). This framework enables ex-ante analysis that combines Williams (2021) three circular city development actions by Williams (2021) (i.e., looping, ecological regeneration, and adaptation) with Nilsson et al. (2012) three levels of policy analysis (i.e. objectives, instruments, and implementation). The need for ex-ante analysis arises due to the limited duration of circular economy policies (Bassens et al., 2020), which makes ex-post analysis impractical. However, ex-ante analysis can be achieved by examining policy coherence, assessing the alignment and synergies between policy objectives, instruments, and implementation practices. This approach holds promise as an early policy analysis tool, helping to identify integrative opportunities, such as the combination of looping, ecologically regenerative, and adapting actions, to promote circular built environments (Bucci Ancapi, 2023). Looping actions include recovery, recycle, reuse, and other circular strategies associated with the so-called 'R-Ladder' (cf. Potting et al., 2017). Ecologically regenerative actions promote the regeneration and support of ecosystem (services) degraded by historical processes of unsustainable urbanisation. Adapting actions in turn seek to enhance and support capacity building and adapt both the urban and social fabric to change. The combination of these three actions, as explained in section 1, can contribute to shifting from a predominant circular economy to a circular city approach that prioritises functioning of systems of urban provision over economic growth and production efficiency. This combination allows the analysis of policy coherence both in terms of content (circular city development) and process (policy making) within one or more policy domains. The framework also allows for the coverage of different policy domains within the city scope, such as food, transport, construction, and planning. For this article, two domains are included to assess policy coherence in circular city development: circular economy (i.e. 5 circular economy policy documents), as an emergent policy domain, and spatial development (i.e. the London Plan).

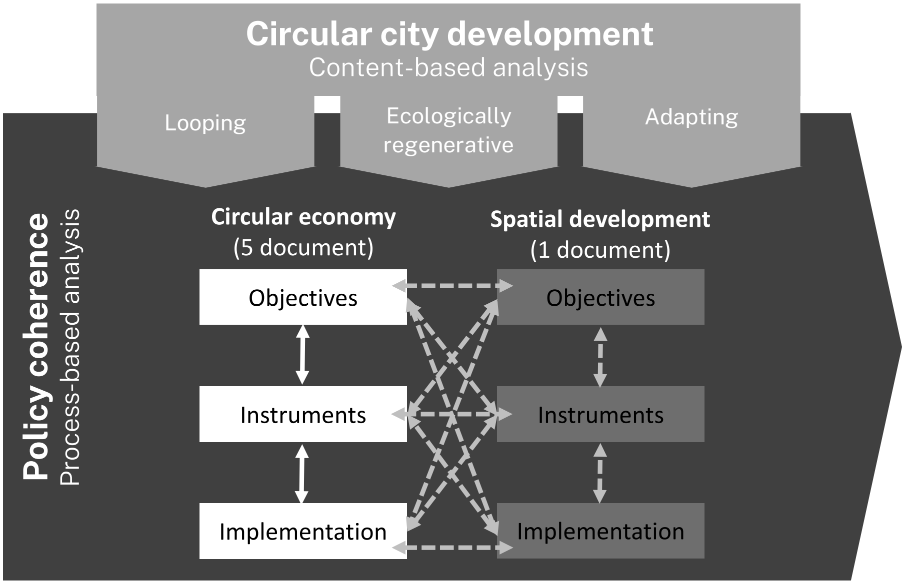

FIG. 5.2 Circular city policy coherence framework. Adapted from Bucci Ancapi (2023)

5.3.1 Evidence

Six policy documents specifically related to a circular built environment were used to analyse the coherence between circular economy and spatial development policies in Greater London. The documents were collected through exploratory interviews with researchers at the Bartlett School of Planning, University College London. The different policy objectives and instruments contained in the selected policy documents are listed in Appendix II. All documents were produced by the Greater London Authority between 2015 and 2021. The analysis is based only on documents that explicitly consider circular built environment objectives. This decision to set the system boundaries around policy documents with a clear circular economy orientation avoided the inclusion of documents developing waste management frameworks (Bucci Ancapi, 2021). All documents are publicly available.

Six semi-structured interviews were conducted between March and April 2023 with representatives from ReLondon, the UCL Bartlett School of Environment, Energy & Resources, the London Energy Transformation Initiative (LETI), the UK Green Building Council, the Building Research Establishment, the Mayor's Design Advisory Group, and a bio-based design and construction company. These interviews aimed to further identify policy objectives, instruments, and implementation practices. The interviews followed the analytical steps and template of Nilsson et al. (2012), namely: the inventory of policy objectives, a review of interactions, and a more detailed mapping of key interactions. For further coherence analysis on implementation practices, the interviews also integrated the factors for policy coherence analysis of Ranabhat et al. (2018), which distinguishes five factors, namely: motivation, measures, implementation plans, resources, and monitoring and evaluation aspects of policies and policy instruments.

5.3.2 Analysis

Computer-assisted qualitative data analysis (QAQDA) using Atlas.ti 23.3 software was used to analyse the documents. As the interviews were structured according to the template and factors included in section 3.1, the responses were consolidated in MS Excel for text analysis. The coding process consisted of three rounds. The first round was open coding, which aimed at identifying information of interest. The second and third rounds were theoretical coding, aimed at identifying references to policy levels, circular actions, and factors of policy coherence. 11 codes were generated and used in the analysis. The interviews were conducted and recorded in English with prior informed consent. The identification of circular actions in the selected policy documents distinguished between actions that were explicitly and implicitly mentioned. Explicit references included concrete applications of circular actions (e.g., modular construction, the reuse of specific building components, recycling of construction and demolition waste) while implicit references included general ambitions to apply circular actions (e.g., resource efficiency or waste reduction). Once all documents were analysed, cross-checks were carried out by the authors to ensure a correct extraction and interpretation of the data. The datasets are publicly available in the 4TU Research Data repository[9]. To know more about the operationalisation of the Circular city policy coherence framework in relation to this case study, see Appendix IV.

9 https://doi.org/10.4121/1eeaab32-302c-4ab6-926f-7ecf1b73d8b9.v1

5.4 Results

5.4.1 Assessing circular actions

Circular actions in the policy domains of circular economy and planning were assessed. In terms of circular economy policies, most actions correspond to looping, followed by adapting ones. Looping is included through actions to reduce the use of primary resources, substitute unsustainably sourced resources with sustainably produced ones, develop new design and production processes and promote new ways of consuming, reuse secondary resources, reduce waste, develop markets for secondary resources, include looping actions in policies and regulations, and create and gather knowledge on economic opportunities, circular innovation, resource cadastres, and scoping for circular economy implementation. All these measures were explicitly mentioned in the selected policy documents. In terms of adaptation, actions aim to produce durable infrastructure that can adapt over time while meeting current needs; to use buildings more effectively through better urban planning, office sharing, and the reuse and multiple use of buildings; to change the behaviour of residents through recycling programmes; and, to build capacity and skills within public authorities through workshops, webinars, events, toolkits, and guidelines. These references include both explicit and implicit references in selected documents. No reference to ecological regeneration was identified in circular economy policy documents.

The spatial development policy (i.e. the London Plan) included all three circular actions. However, adapting ones were only implicitly mentioned. Looping actions include promoting the circular economy to improve resource efficiency and innovation to keep products and materials at their highest use value; preventing and reducing waste through resource reuse; achieving or exceeding 95% reuse/recycling/recovery in the medium term; incorporating circular economy strategies in the design, planning, construction and deconstruction of new buildings; and, achieving zero carbon in major developments by means of reducing greenhouse gas emissions from operations and minimising annual and peak energy demand of buildings. All of these actions are explicitly mentioned in the selected documents. Ecological regeneration actions include the identification, protection from harmful development and expansion of Sites for Nature Conservation (SINCs), urban forests, woodlands, green and open spaces through (cross)borough collaboration (e.g. London's Green Belt and Metropolitan Open Areas); the integration of ecosystem services into major development through high-quality landscaping (including trees), green roofs, green walls and nature-based sustainable drainage; to ensure biodiversity benefits in new developments; and the protection of existing allotments for urban agriculture and their possible expansion through new development and vacant or under-utilised sites in London. All these actions are explicitly mentioned in the documents. The London Plan also includes the Urban Greening Factor, a scoreboard for integrating greening in new developments. It facilitates and frames greening in major developments overseen by the Greater London Authority. Interviewees expected that urban greening is to be extended to smaller projects managed by the boroughs to ensure sufficient greening in new developments. Finally, adaptation actions refer to collaborative efforts to develop green infrastructure strategies to optimise green infrastructure across boroughs. Figures 5.3 are visualisations of the code co-occurrence between the focus of circular actions (loop, adapt or regenerate) and the policy levels (objective, instrumentation, or implementation) in the analysed circular economy and planning policy documents, respectively. Table 5.1 summarises the references to circular actions in the policy documents.

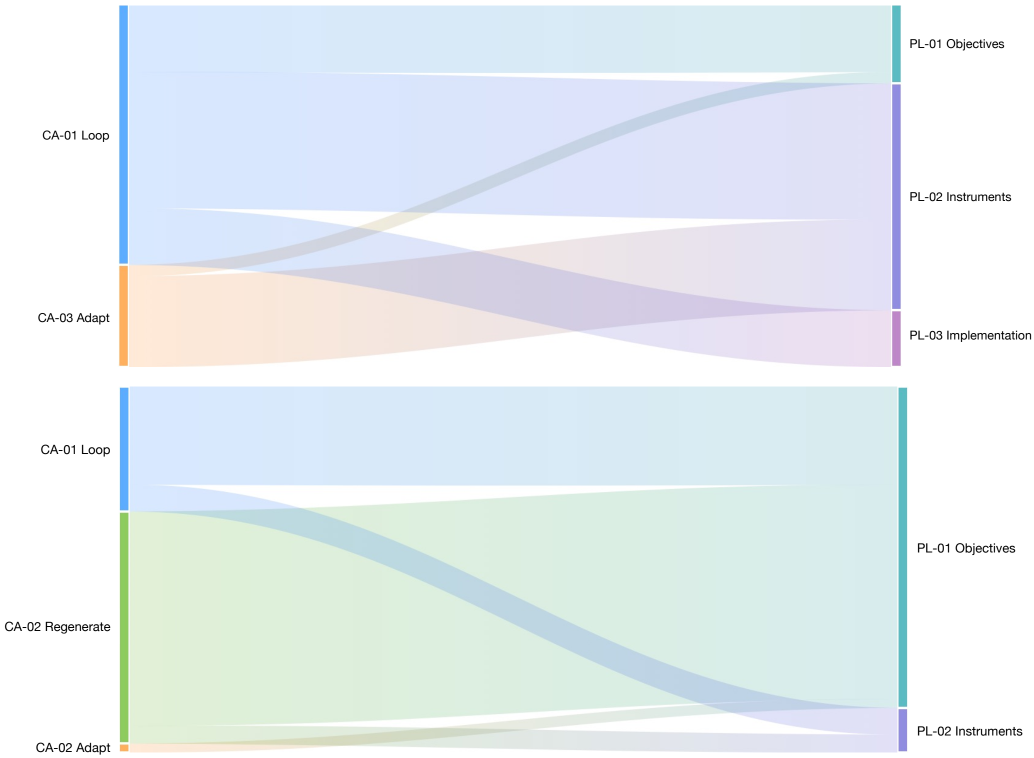

FIG. 5.3 Circular actions (CA) regarding policy levels (PL) for circular economy (above) and for planning policy (below). Atlas.ti code co-occurrence analysis by the authors.

TABLE 5.1 Circular actions covered in selected policy documents.

Policy domain	Documents	Circular actions		
		Loop	Regenerate	Adapt
Circular economy	Towards a circular economy (2015)	e		i
	Circular Economy Route Map (2017)	e		e
	Design for a Circular Economy Primer (2019)	e		
	2020-2025 Business Plan (2020)	e		e
	Circular Economy Statement Guidance (2020)	e		e
Planning	London Plan (2021)	e	e	i

Note: e= explicit reference; i= implicit reference.

5.4.2 Analysing policy coherence

5.4.2.1 Overall policy assessment

London's circular built environment policy shows increasing coherence across both circular economy and planning policy domains. Sparked by an initial mayoral request in 2015, circular economy policies have evolved from a document designed to raise awareness among businesses and waste management organisations to a more elaborate set of objectives and instruments. This has also driven vertical (or top-down) policy alignment in Greater London. However, as circular economy policies have only been in place for a short time, their impact in Greater London has been limited, as most objectives have not been operationalised within the period studied. In terms of planning policy, the inclusion of circular economy principles in spatial development creates a binding obligation for new developments in Greater London, which can lead to changes in construction and development towards more circular practices.

5.4.2.2 Key synergies and conflicts

At the level of objectives, no conflicts were identified to become a more resilient, resource efficient and competitive circular city in the future, which is the vision for London contained in the 2017 Circular Economy Route Map. A set of twelve overarching objectives were identified among policy documents (Appendix 1). These objectives cover waste reduction; primary and secondary resource management;

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developing new ways of designing, producing, and consuming; developing markets for circular products and resources; evaluation and monitoring processes; policy, legislation, and regulation; knowledge, innovation and awareness; capacity building; adaptation; accelerating the circular economy; and, ecosystem conservation and urban greening.

Synergies and conflicts can be found at the level of instruments. The eight years of circular economy policy development in Greater London has allowed the inclusion of instruments specifically designed to operationalise some of its objectives in the construction sector. Fifty-five instruments were identified in relation to the twelve objectives (see Appendix 1). Although the London Plan comes into force in 2021, the Circular Economy Statement was created in 2020 and included in policy SI7 of the London Plan. This is arguably London's most advanced instrument for the circular economy as it establishes a compliance obligation for new developments at the Greater London level, and its future inclusion in development plans at the borough level. It is worth noting that the completion of the Circular Economy Statement relies mainly on future assumptions and the description of actions, which are not supported by indicators that could enable their evaluation. The co-existence of the Circular Economy Statement and the Urban Greening Factor in the London Plan, has also the potential to align ecosystem services provision in the built environment with circular economy principles. This is evident in the Urban Greening Factor guidelines, which require project design briefs to look for synergies between the Urban Greening Factor and other policy requirements in the London Plan. The guidelines provide a list of policy priorities in the London Plan, but policy SI7 is not included. During the interviews, the Royal Institution of Chartered Surveyors' (RICS) Whole Life Carbon Assessment tool for the built environment was identified as another policy instrument that can be combined with the Circular Economy Statement to deliver more circular construction. However, this instrument is neither mandatory nor of public origin, and was therefore not identified in the selected documents or included in the analysis. An apparent conflict or obstacle to achieving a more circular city lies in the limited circular city actions related to existing buildings and their refurbishment. While retrofitting is considered in circular city policies, ecological regeneration is only applied to new buildings, so the provision of ecosystem services may have an impact on the homes built to accommodate the additional one million residents expected in Greater London by 2040, but not on the existing eight million. One potential issue is the value added tax (VAT) levied on retrofitting, whereas new build is VAT exempt –a conflict that was identified through one of the interviews.

In terms of implementation, little or no information was found on the finalisation of the circular economy policies, their implementation plans, the resources needed per objective and the monitoring and evaluation processes. The 2020-2025 Business

Plan is the only policy document that provides a somewhat detailed implementation plan in terms of budget execution. Five budget lines are included for the period: Resource London Programme, Circular Economy Programme, Revenue Programme, Net Programme Expenditure and Net Investment Expenditure.

5.5 Greater coherence for Greater London

5.5.1 Circular city policy coherence and the built environment

Both expected and unexpected findings emerged from the study of circular city policy coherence in Greater London. Given the history of looping and adaptation of circular actions for the built environment in Greater London (Williams, 2021), it was expected that a more developed set of objectives and instruments would be found in circular economy policies and as a result of its recent inclusion in planning policy. This was evident for the case of the Circular Economy Statement, which sets out circular economy strategies for buildings regarding its design, planning, construction, and their function adaptability. The observation of only limited monitoring and evaluation of existing policies was also to be expected, as recently noted by Turcu and Gillie (2020) across boroughs in Greater London, and in another case study in the Netherlands by Bucci Ancapi (2023). The continued underdevelopment of meaningful indicators for the circular economy seems to be related to its novelty and the ever-increasing demands for its operationalisation. Compared to the energy transition in the built environment, which is mostly developing around concrete and measurable indicators of CO_2 equivalent emissions and energy use efficiency (i.e. wattage), the circular economy faces a difficult multi-level process of policy formulation, with local and supra-local authorities such as the GLA waiting for national frameworks to follow. However, in the UK, austerity policies are limiting the powers and capacity of local government to act (Turcu & Gillie, 2020). During the interview with the manager of the circular built environment projects at ReLondon and a researcher at the Building Research Establishment, the interviewees mentioned that some circular built environment initiatives were taking place at a local level, but these were not driving change in terms of circularity of buildings. The interviewee from ReLondon also pointed out that the Circular Economy Statement can only be applied to projects overseen by the GLA, and that the inclusion of the Statement in locally overseen projects depends on the willingness of the boroughs. The inclusion of the Statement in local development was seen as desirable by ReLondon, but they did not know when this could be implemented. The information obtained from these interviews provided a reason not to dig deeper into what the boroughs were doing regarding circular built environment policies at the local level.

The unexpected includes both positive and negative outcomes in promoting a more circular built environment and ultimately a circular city. The inclusion of both circular economy and greening policies in the London Plan is a step forward in aligning policies for a circular, resilient and environmentally regenerative built environment in Greater London. From 2021, major development projects will be required to provide a Circular Economy Statement and an estimate of their Urban Greening Factor, which together with the energy efficiency measures included in the London Plan, will bring a more integrated approach to construction in line with the vision of London as a circular, resilient and energy efficient city of the future and the circular city development policies.

While this policy integration effort helps to create a more circular built environment, it may also represent the further optimisation of circularity in cities as a business-driven concept. After all, the Circular Economy Statement and the Urban Greening Factor are tools for developers, in developments that may or may not involve Londoners. The dominant driver of economic gain, wealth and growth in circular economy policies (Ness, 2022; Williams, 2021), also known as eco-accumulation (cf. Savini, 2019), has not been accompanied with policies to support residents and communities to enable circular systems of provision and new ways of inhabiting and making the city. This is the missing pillar of circular actions in Greater London, as there are measures to adapt the urban fabric but not the social fabric.

5.5.2 Not seeing the city for the buildings

The advantage of analysing policy coherence in the context of circular city development is that it allows the analysis of both process (policy making) and content (circular city development framework). While considering coherence solely in terms of circular economy objectives, instruments, and implementation practices could led to a diagnosis of consistent coherence, it is only when matched to the circular actions of Williams (2021) (i.e. looping, ecologically regenerative, adapting) that synergies and misalignments can be more easily identified, mitigated or improved (Bucci Ancapi, 2023). The dominant technocratic perspective on urban metabolism, a concept that analyses cities as if they were living biological systems that process resource inputs, throughputs, and outputs, has historically been the epistemological lens for the study of circular economy in cities (cf. Wachsmuth, 2012). Urban metabolism has been concretised through widely used analytical approaches such as material flow analysis (MFA), life cycle assessment (LCA), and environmentally extended input-output analysis (EEIO) (Ness & Xing, 2017). As such, urban metabolism has overlooked the issue of (political) power in both the making of the city and the ownership of resources within urban areas (cf. Wachsmuth, 2012). As Savini (2019) concludes, political processes pursuing eco-accumulation through the circular economy have not consistently promoted waste reduction through anti-consumerism practices. Ness (2022) echoes this and brings this claim to circular built environment policies mentioning that so far these policies have not pushed societies to build less by means of adapting existing buildings stock and having a serious discussion about what, where and whether new buildings are needed.

Speculatively for the case of Greater London, although supported by historical evidence of urban governance, neoliberal policies have reduced the powers and capacities of local government and urban politics in general (Pill, 2021). In the case of Greater London, this could be exemplified by austerity policies, as a combination of government budget cuts, privatisation of public services, wage cuts, and the dismantling of the welfare state, which works downwards by allocating risks, responsibilities, and deficits to local government (Schipper & Schönig, 2016). This context conflicts with and hinders the vision of Greater London as a circular city in the future (London Waste and Recycling Board, 2017).

The direction and content of policies and the instruments that deliver them depend on how ideas are framed (Bemelmans-Videc et al., 2003; Howlett et al., 2020). As noted above, top-down policies in the UK have been usually based on centralised decision-making, emphasise technocracy and promote market mechanisms. In itself, this downward flow of policy formulation is not a problem, as multi-level government bodies are mandated to set policy. The problem arises when this downward flow is not paired with transformative bottom-up ventures led, for example, by communities and businesses with secured self-organising capacities (Colander & Kupers, 2014; Kupers, 2020) to foster the more radical societal changes needed to address the ongoing socio-environmental crisis. Moreover, in addition to encouraging bottom-up action, there is a need to improve the readiness of central authorities to identify emerging policy conflicts and obstacles and to adapt policy packages to address them (Bucci Ancapi, 2023; Song & Müller, 2022). Arguably, the current governance of the circular economy in Greater London has not synergistically contributed to more radical changes in the way Londoners inhabit and make the city and its built environment, and thus the concretisation of a circular city remains out of reach (Ness, 2022; Savini, 2019). This study cannot argue that circular economy policies may have deepened the neoliberal turn in Greater London in recent decades, but it can argue that circular economy policies do not contribute to the balance of power between the usual incumbents (i.e. governments, corporations) and Londoners. Herein lies an indication to why policy coherence may fail. According to Browne et al. (2023), there are two main reasons why improved coherence may still not lead to better policy outcomes. The first is a lack of ambition in setting policy objectives, and the second is institutional failure. From the policy document analysis conducted for this research, it can be interpreted that the GLA arguably suffers from the latter and less from the former. From its inception, circular built environment policy in Greater London has evolved from a supply chain-based approach to one that includes its spatial components in the London Plan, demonstrating a growing ambition to integrate circularity into the way the built environment is constructed and operated. However, institutional failures can occur in relation to circular built environment policies, as most of what has been identified in policy documents relates to objectives and instruments. Implementation aspects such as resources, implementation plans and monitoring evaluation (cf. Ranabhat et al., 2018) are not sufficiently covered. For example, the overall evaluation of the Circular Economy Statement in terms of how effective it is in driving the inclusion of circular economy principles in project development is not mentioned and remains an open question in terms of when, how and what will be evaluated to determine its impact.

In terms of the implications of the potential synergies and conflicts identified in this analysis, it can be argued that the circular economy as a policy domain in Greater London has led to concrete changes in planning as a domain. This is evidenced by the inclusion of an instrument in the London Plan, as proposed in the Design for a Circular Economy Primer (Instrument 3.3) (i.e. the Circular Economy Statement). This inclusion, together with the requirement for the Urban Greening Factor in the London Plan, could mean that in future circular economy and environmental regeneration policies will work hand in hand. However, because new building is VAT-exempted while retrofitting is not, this could mean that new build will continue to be the most attractive option in the future, providing circular solutions for new development but not necessarily for the existing building stock in Greater London. It is important to note that given the research design and data collected for this projects, these implications remain speculative.

5.5.3 Validity and reliability

This study had several limitations. Firstly, it only used explicit circularity policy documents for the built environment, without considering broader policy frameworks for waste management. However, this was done to highlight the current state of circularity-specific policy development (Bucci Ancapi, 2023; Bucci Ancapi et al., 2022b). Second, while vertical and horizontal policy interactions across Greater London policies were considered, but more insightful analytical results could be obtained by linking (future) plans developed by boroughs in Greater London. However, a recent study on the status of circular economy in local planning processes in Greater London identified only two general inclusions of a circular built environment (Turcu & Gillie, 2020). Thirdly, as the UK left the European Union in December of 2020, this study did not consider European level policies. Finally, as this study uses an ex-ante analytical framework, it is not possible to determine whether existing policies are effective in changing construction and planning practices nor the extent of their effectiveness in implementation practices.

This study has both theoretical and practical implications. Theoretically, this study provides further validation of the circular city policy coherence of Bucci Ancapi (2023), as this study includes two policy domains and focuses the analysis on vertical and horizontal interactions between domains rather than only vertical ones. This study also updates and extends the findings of Williams (2021) in relation to Greater London and its circular built environment policy, which focuses mainly on looping and adapting actions. In practical terms, this study can inform the Greater London Authority, local authorities, and all stakeholder interested in the development of circular built environment and urban policies in the city. In London, as it points out areas such as adaptation and greening that could be strengthened through synergic policy instruments, for instance, by aligning the Circular Economy Statement and Urban Greening Factor in project evaluation. In other cities around the world, it may help those seeking a better understanding of their current circular economy policy and more effective circular city policy formulation. However, the analytical limitations of this study must be considered and may be overcome by (1) including policy documents from local and (supra)national governments to improve the analysis of vertical and horizontal coherence and (2) gathering data to provide at least a brief analysis of implementation practices in relation to circular economy and circular city ideas. Furthermore, the policy analysis in this study has begun to bridge theoretical and practical aspects of the ongoing critique of the circular economy (cf. Keblowski et al., 2020; Kirchherr et al., 2023; Savini, 2023; Williams, 2019) by providing evidence based on policy as a crystallisation of political power upon which not only a theoretical but also a practical critique can be sustained. Policy analysis can thus be instrumental in enabling what Bassens et al. (2020) identify as the potential of an urban circular economy to move beyond neoliberal urbanism and create spaces for much-needed socio-ecological transformations that sustain humanity in the long term.

5.6 Conclusion

How coherent are circular built environment policies in Greater London? The answer to this question is that circular built environment policies in Greater London have increased their overall coherence through business-driven optimisations in construction practices, but less so in achieving a circular city as conceptualised by the Circular City Policy Coherence Framework. As a major driver of the ongoing socio-environmental crisis, urbanisation and the construction and operation of the built environment require drastic, radical changes to enable more resource-efficient and resilient development in the future. The circular built environment policies implemented in Greater London effectively draw attention to issues of resource depletion, waste generation and potential strategies to address these unsustainable trends. However, deeper and more systemic discussions about the need for new buildings, the maintenance of the existing building stock, and the involvement and adaptation of residents and communities in circular urban development remain largely unconsidered in current policies. Future research could benefit from addressing these issues by constructing and evaluating possible future scenarios in relation to different policy directions. An ex-post evaluation of Greater London's circular built environment could shed light on whether policy implementation is able to overcome the limitations of circular policies in urban development. It could also benefit from analysing the coherence between the built environment and other aspects of circular city development, such as urban food production, which is included in the London Plan but whose spatial implications have not yet been analysed. Future research should also explore the equity implications of neglecting political power in discussions of urban metabolism, echoing to some extent debates by Heynen et al. (2006); Molotch (1976), Wachsmuth (2012) and Savini (2019); Savini (2023). Examining political power dynamics in the design and implementation of circular built environment policies could pave the way for rethinking urban circularity, prioritising holistic, socially embedded sustainability frameworks over isolated metrics. This article concludes by arguing that current policy efforts are insufficient to concretise a more circular city, but this is not to say that what has been done is worthless, as each city must find its own ways to develop more sustainable habits through experimentation and learning (Van den Berghe et al., 2020; Van den Berghe & Vos, 2019; Williams, 2019). Acknowledgement:

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6 How ex ante policy evaluation supports circular city development

Amsterdam's mass timber construction policy

Adapted from: Bucci Ancapi, F., Kleijweg, M., Yorke-Smith, N., Van den Berghe, K., van Bueren, E. (under revision) How ex ante policy evaluation supports circular city development: Amsterdam's mass timber construction policy. *Environmental Management,* X(X), pp. XX-XX.

6.1 Introduction

Mass timber buildings are gaining attention from among policy makers as these buildings align carbon neutrality and circular economy goals to address unsustainable patterns of urbanisation (UNEP, 2023). Firstly, mass timber, or the group of engineered wood products resulting from the aggregation of smaller wood elements, is one of the most prominent alternatives to conventional building materials in reducing carbon emissions (Buchanan & Levine, 1999; Churkina et al., 2020; Gustavsson & Sathre, 2011; Pajchrowski et al., 2014). Substituting today's conventional building materials, such as concrete and steel, with mass timber could reduce carbon emission up to 69% in the construction phase, as well as contribute to a potential 9% reduction of global carbon emissions by 2030 (Himes

& Busby, 2020). Second, mass timber holds the promise of achieving a circular built environment, because it integrates circular building strategies such as modular design, design for disassembly, the reuse of components (e.g., walls, windows) rather than recycling of materials (e.g., timber, glass). In short, mass timber construction supports the upcycling of building components, thus potentially extending the life of building materials and reducing the use of new raw materials and the generation of waste and emissions from the construction sector (Ghobadi & Sepasgozar, 2023).

Circular cities are "*complex urban systems in which resources are looped, the ecosystem is regenerated and the socio-technical systems (infrastructure and communities) evolve with changing context*" (Williams, 2021, p. 158). One of the aims of a circular city is thus to reduce the use of non-renewable resources such as energy and materials, which, in turn, reduces waste and emissions, steering clear of the linear "make-use-waste" model of urban development (Paiho et al., 2020; Williams, 2019, 2021). Therefore, mass timber construction aligns with the development of circular cities as it can enable resource looping through the reuse of building components, can contribute to more regenerative practices through sustainable forestry practices, and meet future needs through infrastructure and building adaptation by modular construction. While promising and contributing to achieve two important ongoing urban policy goals around the world, namely circularity and carbon neutrality (UNEP, 2023), the adoption of mass timber construction has been rather slow in countries that have promoted its use since the 2010s (Franzini et al., 2018); doubts about its fire resistance, competitiveness, price, and durability are among the main reasons (Ghobadi & Sepasgozar, 2023). From a carbon accounting perspective, a recent article and report by Peng et al. (2023) and the World Resource Institute (2023) have critiqued the current and future status of the mass timber resource base, pointing out that (1) wood harvesting has negative consequences for carbon emission reduction, (2) most of the wood and its stored carbon is lost during production, and harvesting wood is not carbon neutral, and (3) the use of wood in construction will most likely increase climate warming for decades. These critiques highlight that the potential positive climate impacts of mass timber construction depend on the resource base (e.g. how, where, and what timber is produced) and not only on the circular use of mass timber.

This article focuses on the role of policy actions in achieving the uptake of mass timber construction. While policies to promote timber construction in cities are increasingly being adopted, an important explanation for the achievement of these policy goals lies in the policy actions through which policies are implemented (Bemelmans-Videc et al., 2003; Howlett et al., 2020). Different policy actions could incentivise timber construction in European cities. Indirectly, timber construction can be promoted by reducing environmentally damaging resource use, for example, through climate and product policies. Directly, policies can support timber construction processes and products as well as naturally occurring materials, or the resource base (e.g. supply-push policies) (Hildebrandt et al., 2017). To date, mass timber has only indirectly become a policy option to reduce construction emissions at the European level (EC, 2021) and only secondarily to the need to protect and enhance forests across the region for carbon removal (European Council, 2023). In 2010, there were no policy actions directly supporting timber construction at the European level, but also no formal barriers to the increased use of timber in construction (Tykkä et al., 2010). This context remains in 2022. The “Fit for 55” climate package adopted by the European Union (EU) includes policy instruments that directly affect forest management and timber production, i.e. the New EU Forest Strategy for 2030, the EU Renewable Energy Directive, and the Regulation on Land Use, Land Use Change and Forestry. However, these policy instruments do not directly promote timber construction (EC, 2021).

One of the European cities that has set a policy objective to achieve timber construction is the Dutch city of Amsterdam, especially with its Green Deal Timber Construction (Metropoolregio Amsterdam, 2021), a multi-actor agreement to support mass timber construction with the goal of incorporating at least 20% of timber in new build by 2025. This agreement signed by key stakeholders in the building sector follows the long-term policy objective to transition to a more circular city and a decade of circular city policy development (Gemeente Amsterdam, 2020). Amsterdam provides an excellent case study to examine the effect of policy actions for mass timber constructions. The Netherlands Environmental Assessment Agency (PBL) concluded that ill-equipped circular economy (CE) policies in the Netherlands must be provisioned with more forcible instruments (i.e. regulations, standards, economic stimuli) (cf. PBL, 2021). All in all, the status of the circular city policies in Amsterdam can be categorized as driven by economic development and lacking policy actions in relation to the built environment, spatial planning, and the inclusion of nature based solutions, a situation that could affect the effectiveness of such policies (Calisto Friant et al., 2023). Further at the European level, CE policy instruments have proven ineffective. More than €10 billion worth of economic stimuli designed to incentive CE innovation and adoption were ineffectively deployed to solve waste management issues (European Court of Auditors, 2023). Arguably, ineffective CE policies can be linked to a lack of policy coherence: the (mis)alignment and synergies between policy objectives, instruments and implementation practices.

Given the scale of the built environment, any policy aimed at change is, in principle, a long-term policy, and given the current state of circular city policy in Amsterdam, ex-post policy evaluation, the dominant form of policy evaluation that takes place after a policy has been implemented (cf. Howlett et al., 2020; Wollmann, 2009), is not useful for assessing the effectiveness of policy actions in relation to timber construction in Amsterdam. Instead, ex ante policy evaluation, aimed to hypothetically anticipate the effects and consequences of policy actions by means of the analysis of chosen policy objectives and instruments, might inform policy formulation and improve the effectiveness of recently emerged policies for mass timber construction (Boero, 2015; Wollmann, 2009). Hence, this article poses the following two research questions: *How coherent are policy actions for timber construction in Amsterdam?* and *how can ex ante policy evaluation inform policy formulation for timber construction in Amsterdam?*

The aim of this article is to assess the potential effect of policy actions in support of mass timber construction by means of *ex* ante policy analysis in Amsterdam. The paper is structured as follows. The next section presents the theoretical framework based on policy formulation and ex ante policy evaluation. The methods and materials used in this article are then explained. The results are presented in relation to the coherence and ex ante evaluation of policy measures for timber construction in Amsterdam. Finally, discussions and conclusions are presented in relation to the research questions of this article.

6.2 Background

6.2.1 Policy formulation and evaluation

Public policy can be understood as a set of interrelated decisions taken by political actors to select objectives and the means to achieve them (actions) within the limits of their authority (Jenkins, 1978). Policies are usually studied and to some extent developed according to the so-called policy cycle or process, which includes five stages: (i) agenda setting, which refers to how problems are brought to the attention of government; (ii) policy formulation, that involves the development of policy options within government; (iii) decision making, which is the process by which governments choose a course of action or inaction; (iv) policy implementation, that refers to the implementation of policies; and (v) evaluation, which involves monitoring and assessing outcomes, possibly leading to revisions in policy problems and solutions (cf. Howlett et al., 2020; Jann & Wegrich, 2017).

For this article, formulation and evaluation are of particular interest as they deal with the selection of policy actions and their evaluation at the end of the policy cycle. Formulation and evaluation differ from the other stages in the policy cycle in that they are 'backroom functions' (Fischer et al., 2007), which refers to more technical processes that often involve fewer people than agenda-setting, decision-making, and implementation. Policy formulation aims to translate policy objectives into concrete actions and demonstrable results (Bemelmans-Videc et al., 2003), these actions are in many cases concrete policy instruments[10] that can be divided into three generic types: regulatory (e.g. laws, regulations, standards), economic (e.g. subsidies, grants, taxes), and information (e.g. guidelines, information systems, awareness campaigns) (Vedung, 1998). In some other cases, policy actions involve the willingness or commitment of political actors to make progress in certain directions (expected instruments) in the future, for example, a commitment to legislate in the future about a certain matter as part of a broader set of policy actions and instruments. This article resorts to the concept of policy actions in need to make sense of the many policy activities that cannot solely be identified with usual concepts as policy instruments. Policy evaluation is a formal or informal retrospective (*ex post*) assessment process of policy outputs and outcomes, which is carried out after the implementation of the policy so to determine whether the policy objectives were achieved. The evaluation normally comprises either the assessment of the policy *processes* by means of inputs and outputs, which is meant to provide relevant information for the implementation phase (Wollmann, 2009), or *impacts* based on the effects of the policy (Howlett et al., 2020).

On this basis, circular city policies have started to gain attention regarding their formulation and evaluation. Although research on circular cities has grown rapidly since 2015 (Bucci Ancapi et al., 2022a), its governance aspects have only recently been addressed. Amsterdam has been of special interest for research as the city has developed circular city policies over a decade. According to Williams (2023), Amsterdam has adopted a city-wide circular tendering policy to promote circular city development, resulting in new circular building networks for the use of recycled concrete and modular construction, and the demonstration of circular building methods. Other actions have integrated circular principles in the built environment, namely, (i) high value reuse and recycling, (ii) smart design, (iii) resource exchange, and (iv) improved separation of waste streams (Williams, 2021). While Amsterdam has advanced circular city policies, these policies have also been criticised given their narrow economic focus. According to Calisto Friant et al. (2023), circular city policies in Amsterdam focus on economic competitiveness and technological innovation but overlook its social, political, and ecological implications.

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10 Also known as policy tools or governing instruments.

Indeed, their findings highlight main areas of policy development: governance and municipal operations, food and organic waste streams, and education and knowledge development. On the contrary, the built environment and territorial planning, ecosystems and nature based solutions, and renewable energy are the least development areas. Specifically on the analysis of circular city policies, Bucci Ancapi (2023) developed a circular city policy coherence framework to analyse the (mis)alignment of policy objectives, instruments, and implementation practices in the transition towards circular cities (Figure 6.1). The use of the circular city policy coherence framework identified a similar trend in circular built environment policies at the national level in the Netherlands, where most policies are equipped to foster circular supply-chains in the built environment, but not necessarily contributing to the development of a circular city. Additionally, the analysis of circular built environment policies in the Netherlands showed the lack of consistent set of policy instruments to facilitate the transition (e.g. regulations, material passports, market formation, and economic stimuli) (Bucci Ancapi, 2023).

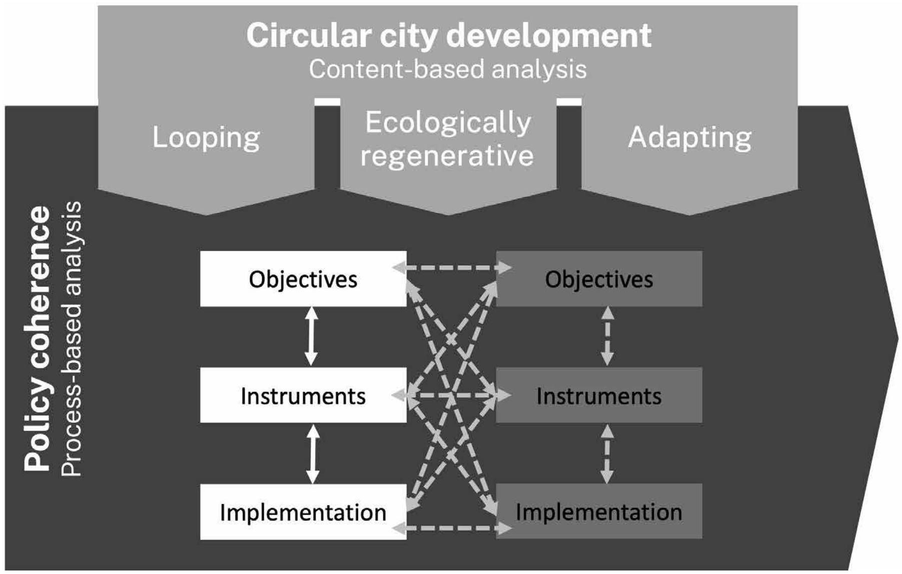

FIG. 6.1 Circular city policy coherence framework. Source: Bucci Ancapi (2023).

Note: looping actions, akin to the 'R-Ladder' concept (Potting et al., 2017), involve reuse, recycling, and reduction strategies; ecologically regenerative actions aim at restoring ecosystems affected by unsustainable urbanization, for example through blue and green infrastructure and urban ecosystem services provision; and adapting actions focus on enhancing capacity-building and resilience to changing conditions across urban communities (Williams, 2019).

6.2.2 Ex ante policy (instrument) evaluation

Another category of public policy evaluation has been developed in conjunction with the development of computer simulations: *ex ante* evaluation (Boero et al., 2015). In contrast to ex post evaluation, ex ante evaluation is carried out before a policy is implemented. Its purpose is to support policy formulation or the choice and design of policy objectives and instruments and to (possibly) anticipate and pre-assess a policy's effects and consequences (Howlett et al., 2020; Wollmann, 2009). According to Boero (2015), two issues in policy formulation make ex ante evaluation useful, at least scientifically, let alone its convenience to explore the robustness of public policy, namely: (1) easy enthusiasm for a policy choice and (2) addressing issues that have recently emerged. The first issue has to do with policy choices that are gaining support at rapid pace, the consequences of which may seem whimsical and the possible outcomes of which are not properly understood. The second, which is of central interest to this paper, has to do with emerging issues for which knowledge is not sufficiently collected or developed; for example, the circular economy (cf. Kirchherr et al., 2023; Korhonen et al., 2018).

Computer simulations, such as those performed through Agent-Based Simulation (ABS), have facilitated the study of complex systems in many policy areas, including the built environment (Gaudiano, 2013; Meadows et al., 1972; Portugali et al., 2012). ABS is a computer-based modelling approach used to represent, compute, and explore the effects of complex assumptions of relations between social actors and the systems they are embedded in (Ghorbani et al., 2014; Zellner, 2008). These models make use of both structural data (i.e. data that specifies the model structure and functioning) and emergent data (i.e. data resulting from running the model that accounts for the behaviour of a system as a whole) (Gaudiano, 2013). ABS develops object-oriented computer programs, wherein objects are actors making rule-based decisions in an environment that is also modelled. Both actors and the environment possess specific attributes that condition their overall behaviour in the system. For instance, in the built environment, actors can be building owners, developers, demolition companies, among others. The built environment (the model's environment) can be featured with different building typologies and parameters (Gaudiano, 2013).

ABS is used in ex ante policy evaluation. As ABS are usually based on rule-based decisions (just like policy instruments), they are particularly useful for describing how agents with different information, decision rules, and unpredictable situations interact with each other and what the outcomes of such interactions might be (González-Méndez et al., 2021; Lempert, 2002). ABS is useful to test the effect of specific policy actions in target groups, and convenient for *ex* ante policy evaluation when such experiment are costly or risky in real life (i.e. subsidies, taxes, zoning) (Epstein, 1999;

Zellner, 2008). A major benefit of ABS is that they can provide policy and behavioural recommendations to political actors in anticipation of the plausible outcomes of their decisions, provided that an appropriate institutional framework is in place. ABS can also can also provide visualisation tools for policymakers in collaborative learning activities (Zellner, 2008). ABS can also help policymaking by providing quantitative support to policy stakeholders (Lempert, 2002). The main limitations of ABS lie on its predictive power, the result variability of the same parameters when the model is repeated, and the dependency on the model's assumptions (Manzo, 2014; Zellner, 2008). However, this limitation is also a result of misconception, for it is not the aim of ABS to provide recipes for action. Instead, the advantage of modelling actor-environment interactions resides in allowing the understanding of a wide range of emergent relationships through parametric variables that would be otherwise difficult to obtain (Epstein, 2008; González-Méndez et al., 2021). In other words, ABS can unveil the complexity embedded in the modelled actor-environment system, be informative on how actions might work out, and possibly deliver ex ante evaluation of actions.

6.3 Materials & Methods

This article explores ex ante evaluation of policy actions in support of mass timber construction in Amsterdam. After a preliminary review of policies for timber construction in Amsterdam it was decided to focus on policy actions rather than only on instruments, as many policy choices consider less defined actions to be implemented in the future instead of well-defined instruments (i.e. regulatory, economic and information).

6.3.1 Coherence analysis of policy actions

Firstly, a coherence analysis of policy actions was conducted to assess how aligned they are regarding circular city development. For this purpose, policy actions were gathered from three sources: Amsterdam Metropolitan Region's (AMR) documents 'Green Deal Timber Construction' (Metropoolregio Amsterdam, 2021), the 'Opportunities for financial incentives for timber construction' (Haisma, 2021), and the CircuLaw database on policy instruments for mass timber construction in Amsterdam (CircuLaw, 2023). CircuLaw is a City of Amsterdam initiative for the

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analysis and dissemination of existing regulatory instruments that can be used for circular economy purposes such as mass timber construction. All policy actions identified were classified according to the following criteria (Table 6.1). 'Governance level' refers to the administrative boundary of application (i.e., municipal, provincial, national). 'Status' refers to whether the action is in place or just planned. 'Regime' distinguishes between public or private-led actions. 'Action type' classifies actions in relation to the typology of Vedung (1998) which distinguishes 'sticks' (regulatory instruments like laws, regulations, and standards), 'carrots' (economic instruments such as taxes and subsidies), and 'sermons' (information instruments such as guidelines and information systems). Only actions that explicitly refer to an instrument type were classified as such. For example, 'promotion of wood projects in the city' would not be classified as an instrument, whereas a 'subsidy for wood projects in the city' or 'design guidelines for mass timber construction' would be classified as economic and information types. Both 'circular actions' and 'support actions' are derived from the circular city development framework of Williams (2019). Finally, the 'R-Ladder' is a well-known hierarchy of circular strategies that moves from least circular interventions (i.e., R6 – Recovery of energy from materials through incineration) to utmost circular ones (i.e., R1 – Refuse, abandoning a product by making its use obsolete). Strategies R1, R2, R3 hold the most transformative potential in bringing about a more circular economy (RVO, 2020). The data set can be accessed via 4TU Research data repository[11].

TABLE 6.1 Criteria for policy instrument classification

Governance level	Local	Provincial	National			
Status	Active	Inactive				
Regime	Public	Private				
Action type	Regulatory	Economic	Information			
Circular actions	Loop	Adapt	Ecological regeneration			
Support actions	Substitution	Optimisation	Localisation	Share		
R-Ladder	R6 - Recover	R5 - Recycle	R4 - Repair	R3 – Re-use	R2 - Reduce	R1 - Refuse

11 https://doi.org/10.4121/240d3907-d6cf-40a3-b4ff-08779f1a13ab.v1

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6.3.2 Agent-based simulation for policy instruments

Secondly, an ABS was modelled using NetLogo for the ex-ante evaluation of policy instruments for timber construction. The ABS includes the interaction of agents in the built environment (i.e. households, companies, housing associations, houses, material suppliers, demolition companies and construction companies) and the residential and commercial buildings of Amsterdam, including building-related parameters (i.e. material intensities, building distribution, floor area, recycling rates and ownership distribution). The full dataset for this model, including the source of all parameters and a full description of agent interactions and assumptions in the models, can be found in Appendix III. To populate the model accurately, physical parameters of Amsterdam's buildings were quantified. While not a one-to-one spatial representation, the current building stock is assessed using relevant parameters to create a simplified and scalable model. A simplified model is suitable for this ABS given the computational intensity of a real-scale model and given the purpose of this paper to only illustrate the usefulness of ABS in ex ante policy evaluation. The data set can be accessed via 4TU Research data repository[12].

The NetLogo model consists of patches on a 2D grid representing residential or commercial buildings, such as apartments, houses, shops, and offices (N=6,835) (Statistics Netherlands, 2023b). Specifically, the 2D grid visualization does not reflect real spatial layout, with buildings randomly placed. Grid size does not correspond to real-world dimensions. Subcategories enable detailed data on construction years, floor surfaces, and material intensities. The model relies on a Weibull distribution for its accurate performance in material flow analysis, resulting in a mean lifespan of 63 years (Deetman et al., 2020). Material intensity derived from a material flow model of the Dutch city of Leiden (Yang et al., 2022), as this research did not count with material intensities[13] for the city of Amsterdam. This model assumes Amsterdam buildings use masonry initially and resorts to the estimation on material intensity for masonry buildings in the Netherlands by Sprecher et al. (2022) and an estimation for timber buildings derived from a construction portfolio by Smith and Wallwork Engineers (2023) as data on timber buildings is scarce. Few mass timber buildings exist in the city (Metropoolregio Amsterdam, 2023), at the time the study was done.

In the Netherlands, 95% of building demolition waste is recycled, mainly for low-value applications like road construction, and less than 3% of secondary materials are re-used in building construction (Schut et al., 2016). End-of-life collection rate

12 https://doi.org/10.4121/60767525-12ff-4c7d-8bc4-25722e400689.v1

13 Material intensities show material per square metre and when multiplied by floor surface results in a material intensity estimation per building.

was estimated at 85% for concrete and 95% for timber, while the recycled content potential was estimated at 50% for concrete and 90% for timber (Verhagen et al., 2021). From all construction and demolition waste in the Netherlands, concrete and masonry materials account for 64% and wood accounts for 6%; most concrete (78%) is downcycled as road base material and most wood (76%) incinerated (Zhang et al., 2020). An important limitation of the model lies in not including building renovation processes and a primary focus on new construction. This is due to the difficulty in modelling the work of renovation companies and the re-use of small, tailored wood components.

Construction costs between masonry and timber buildings vary and depend on builders' expertise with materials. For this study, material and labour costs were included as construction costs. A timber building is estimated as +35% in relation to a masonry one in the Netherlands (Beijers, 2021). Labour costs were also estimated at 55% of total construction costs (Shet & Narwade, 2016; Statistics Netherlands, 2023b; Vipin & Rahima Shabeen, 2019). Costs of material, cost per square metre constructed and the ratio of material cost as a percentage of total construction were calculated, which allowed to determine a learning rate for construction using Wright's Law or Learning Curve Effect $C(N) = C1N-\beta$ (Mályusz & Varga, 2017).

Agents in the model use an asynchronous messaging system to communicate construction and demolition instructions, invoices, and other relevant information. Each agent has an inbox and an outbox, systematically processing messages and taking appropriate actions. Messages are then moved to the outbox for transmission to relevant agents, facilitating ongoing communication throughout the simulation.

With each iteration, the model proceeds as follows (Figure 6.2). Owners assess their building stock, initiating demolition, and construction cost requests, while also reviewing construction estimates and forwarding commissions to architecture and construction companies. Construction companies handle material cost requests, manage projects, and send construction cost estimates to owners. They subsequently update construction time and parameters, and remove completed projects. The demolition company adds projects, dispatches secondary materials to the supplier, and updates demolition parameters, then to remove completed projects. The demolition company then clears material stock and sends a secondary material request to the supplier. The material supplier calculates material costs, sends responses to construction and demolition companies, and updates material stock. The model checks for messages in outboxes, sending them from sender's outbox to receiver's inbox.

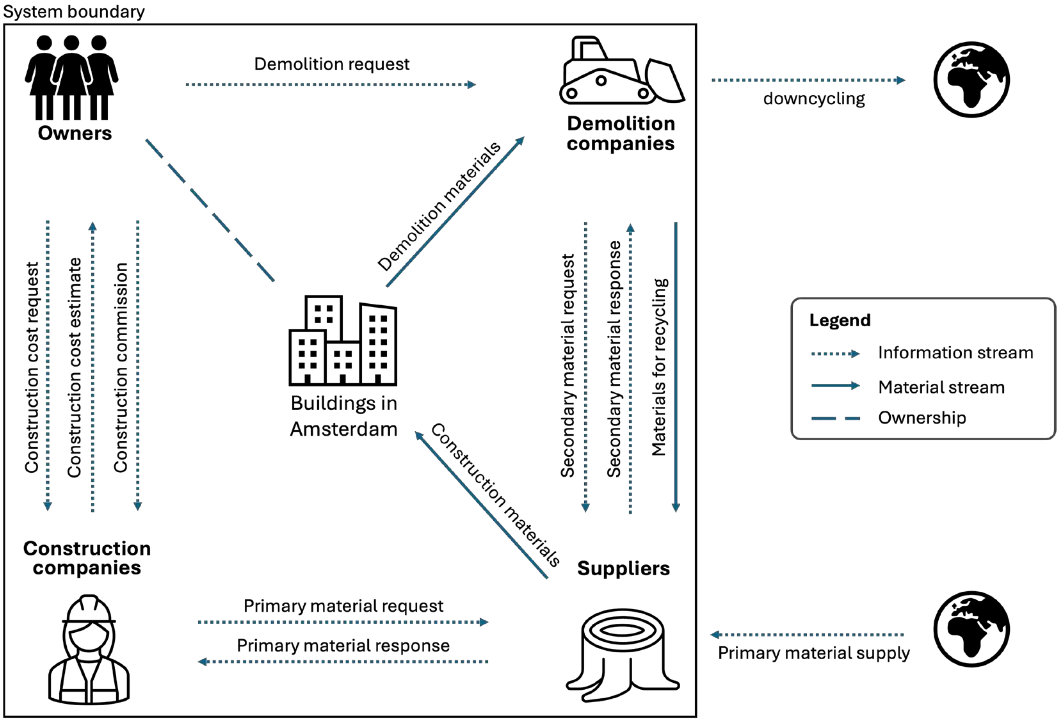

FIG. 6.2 Information and material flows in the model's built environment. Source: the authors.

The model underwent rigorous verification to ensure its validity and the reliability of policy findings. This process included aligning the model description with its actual implementation, conducting a code review, testing boundaries, checking for consistency, analysing step-by-step behaviour, and performing a global sensitivity test on 17 parameters deemed crucial for policy analysis. A total of 18,432 samples were generated for Sobol sensitivity analysis[14], resulting in adjustments to the model to ensure expected behaviour and the absence of anomalies. The complete description of the model, its purpose, entities and state variables and process overview can be found in the Supplementary Materials. In addition, the model was validated on two occasions with circular economy and mass timber experts at the Municipality of Amsterdam. The validation involved reviewing the building parameters and the information and material flows between the model's actors. During the first validation session, experts from the Municipality of Amsterdam pointed out that the real cost of

14 Sobol sensitivity analysis aims to quantify how much each input parameter, alone or in combination with others, contributes to the variability of the model output (Zhang et al., 2015).

timber buildings depends on expertise of architecture and construction companies, which can reduce the cost from the +35% included in the model to zero or cheaper than masonry buildings. This resulted in the addition of a specialisation parameter.

To ensure the heterogeneity of actors in this simplified ABS, the model consists of three kinds of owners (i.e. commercial, private, and public owners), three construction companies, a demolition company, and a material supplier. The three architecture and construction companies are capable of specialising in wood-based or masonry-based construction. Specialisation increases efficiency, reducing construction costs for the chosen material. This specialization creates advantages and disadvantages relative to other companies. Stimuli such as specialisation programmes and subsidies influence owner preferences, further enhancing the expertise of the most efficient construction company in a particular material. However, capacity limitations prevent monopoly by one company. In the model, buildings change through demolition and construction.

6.3.3 Selected policy instruments

The ABM simulates the interaction of three policy instruments. Two policy instruments derived from the analysis of policy coherence and a proxy for a carbon tax were used to test the usefulness of ABS as ex ante policy evaluation tool. The coherence analysis of policy actions described in Section 3.1. was performed prior to the development of the model. From the coherence analysis it was observed that economic instruments were limited and less than a third were active; this was the basis for selection criteria. In addition, according to the instrument typology of Vedung (1998), economic instruments can be negative (e.g. taxes, fees) or affirmative (e.g. subsidies, grants), so it was decided to select instruments that could show the effect of both stimuli in the model. To ensure the accuracy, replicability and simplicity of the instruments in the model, only quantifiable instruments were preselected. The selected instruments are: demolition notification[15] (CircuLaw, 2023), subsidy to timber construction (Haisma, 2021), and a carbon tax proxy that increases the cost of concrete and reduces the cost of mass timber to mimic the effect of a carbon tax. The decision to use only three policy instruments resulted from the need to limit the model's output for analysis, computing power, and the exploratory nature of the study. This is considered an important limitation of the model.

15 A demolition notification is mandatory before a building is demolished in the Netherlands. A demolition notification allows municipalities to monitor which buildings are being demolished and how the process is being carried out. This gives them an insight into the availability of materials, particularly the amount of wood available for reuse in construction (CircuLaw, 2023).

6.4 Results

6.4.1 Policy coherence analysis of actions for mass timber construction

A total of 130 policy actions were identified, of which 80 correspond to instruments. Their classification under the typology of Vedung (1998) and the circular actions of Williams (2019) resulted in the following: regulatory instruments account for 62% of the 80, economic instruments to 16%, and information instruments to 22% (Figure 6.3). Regarding their regime, actions are predominantly of public origin (i.e., regulatory: 59%, economic: 86%, information: 86%). The instruments of private origin were entirely contained in the documents 'Green Deal Timber Construction' (i.e. regulatory: 41%, economic: 14%, information: 14%) (Metropoolregio Amsterdam, 2021). In relation to circular city development, the resulting sample was analysed in terms of circular actions – looping (53%), ecologically regenerative (22%), adapting (25%) – and support actions –substitution (46%), optimisation (21%), localisation (22%), share (21%). There is a clear matching tendency between looping and substitution actions, as mass timber construction switches conventional construction materials (e.g., concrete, steel) by biobased materials. Yet, most policy matches in this regard do not specify the kind of mass timber construction to be considered nor specific circular strategies such as design for disassembly or modular design. Predominantly, identified actions including ecologically regenerative actions do not explicitly refer to ecologically regenerative practices as described by (Williams, 2019), for instance by integrating blue and green infrastructure or ensuring the provision of urban ecosystem services, except for the promotion and contribution to create three multifunctional forests (i.e., forest that provide timber, food, and recreation services). Regenerative actions support mass timber construction as a more ecological option compared to contemporary conventional construction materials and methods. Finally, a quarter of all actions included adaptation actions. Adaptation actions seek to adapt the built environment mainly by including timber in municipal, provincial and national environmental visions[16], allowing experimentation, requesting the inclusion of mass timber in future development, and facilitating and investing in timber education, knowledge and expertise.

16 The environmental vision is instrument included in the Dutch Environmental Act that outlines the key qualities of the physical environment, the proposed development, use, management, protection and conservation of the area. It also details the key aspects of the integrated policy for the physical environment (CircuLaw, 2023).

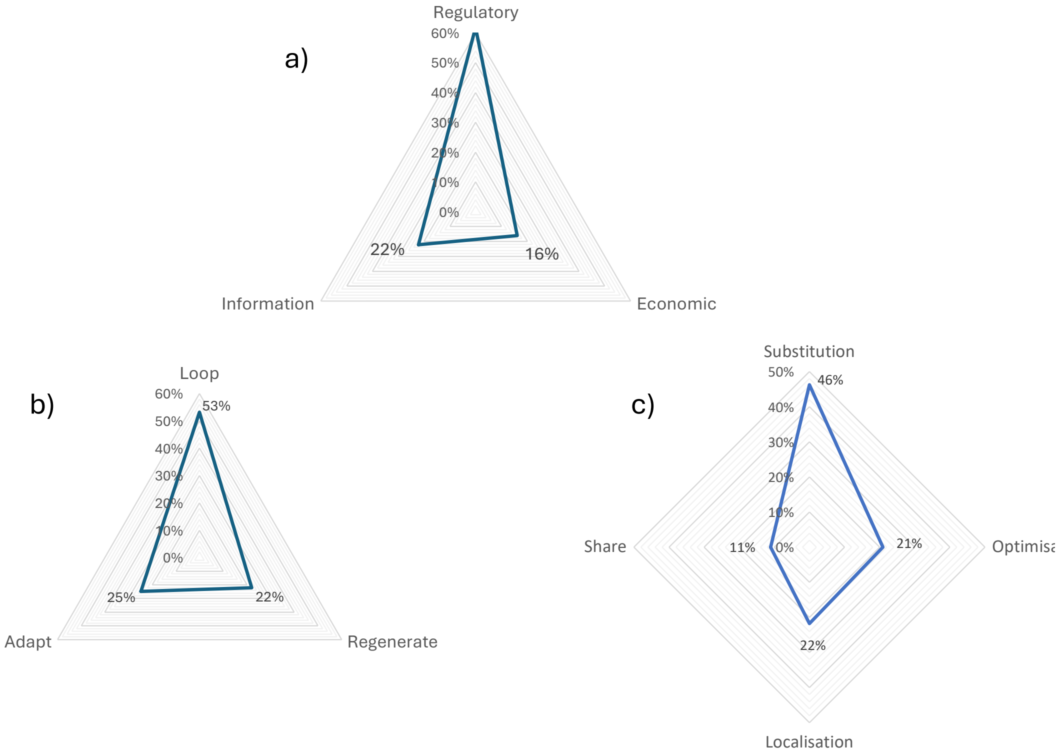

FIG. 6.3 Policy analysis in relation to a) type of instrument, b) circular actions, c) support actions. Source: authors.

6.4.2 Ex ante evaluation of policy instruments for mass timber construction

The ABS conducted for ex ante evaluation of policy instruments to support mass timber construction in Amsterdam yielded several notable findings. The model simulated carbon taxation by elevating the price of reinforced concrete, which is predominantly used in masonry-based construction rather than wood-based construction. This price hike aimed to increase the cost of masonry-based projects in comparison to wood-based ones. While there are instances where the ratio of wood-based construction increases with concrete price increments, the correlation is not consistently significant. Even at the upper limit of concrete price increases, the rise in wood-based constructions is not guaranteed. Another policy simulation involved subsidising mass timber to lower its price. Mass timber is more commonly used in wood-based construction than in masonry-based construction. Thus, reducing the price of mass timber would also decrease

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the relative cost of wood-based buildings. Similar to the impact of concrete price adjustments on construction, a reduction in the model in mass timber prices can only occasionally result in increased wood-based construction on its own.

Combining instruments by implementing both a tax on reinforced concrete and a subsidy on mass timber allows for an examination of their joint effects. Upon each iteration of the ABS, an increase in the proportion of wood-based construction was observed. This shift is attributed to the relative affordability of wood-based projects compared to masonry-based ones, driven by increased demand. Consequently, architecture and construction firms are inclined to specialise in wood-based practices in the model that nonetheless in reality would require re-education and training of staff and possible the purchase of new equipment and the earlier devaluation of existing equipment to increase familiarity among owners. These dynamics contribute to lowering the costs of wood-based construction. Illustrated in Figure 6.4 are 117 combinations of mass timber subsidies (n=13) and concrete taxes (n=9). Green dots signify combinations resulting in a wood-based building ratio higher than zero[17], clustered in the bottom right corner where concrete costs are heavily taxed and wood costs are kept low in relation to their current cost. These results indicate the conditions that would allow an effective use of this policy blend: the difference in costs obtained by the combination of a carbon tax and a mass timber subsidy must be set to reduce the relative cost of timber construction beyond cost-competitive. This means a severe carbon tax rate. These otherwise obvious findings gained relevance in relation to the specialisation of construction companies in wood-based practices, which proved to have significantly affect the construction costs of wood-based projects.

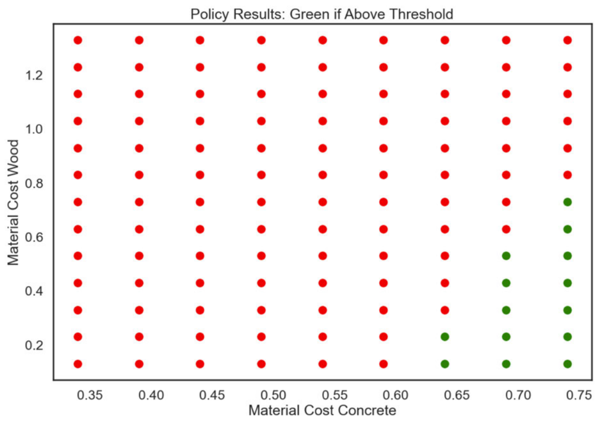

FIG. 6.4 Combinations of a subsidy on mass timber and a taxation on reinforced concrete. Note: Green means that the final wood-based building ratio is non-zero.

17 A wood-based building ratio higher than zero means that at least one building in the model environment is constructed using wood-based materials.

To explore the potential effects of adjusting the upfront specialisation of architecture and construction companies in the ABS, the specialisation component of all architecture and construction firms was adjusted on a scale of 1 to 5, where 1 represents familiarity with masonry-based construction and 5 denotes familiarity with wood-based construction. Increasing upfront specialisation in wood-based construction has a notable impact, particularly when combined with subsidies for mass timber materials and taxes on reinforced concrete, facilitating the adoption of wood-based construction methods (figure 6.5). Furthermore, specialisation rates accelerate beyond a certain threshold, influenced by various factors such as production capacity, which significantly affects the speed and volume of wood-based construction undertaken by companies.

Wood-based construction and circular practices are investigated within the model, offering insight into the interplay between circularity and the built environment. Lower values for parameters such as *ratio_concrete_primary_requested* and *ratio_concrete_landfilled_demolished* signify increased material recycling, reflecting greater circularity in the built environment. Findings reveal a significant correlation between factors such as concrete collection rate, recycling rate, and stock capacity with the amount of concrete landfilled and primary concrete requested. Another correlation exists between increased wood-based construction and the quantity of concrete landfilled, suggesting that any measures influencing wood-based construction would also affect concrete landfilling. Additionally, on the demand side, the selected instruments demonstrate a clear relationship with the demand for primary timber.

Finally, Figure 6.6 displays two runs of the model: one without policy intervention and another with interventions. In run 1, the proportion of wood-based buildings increases over time due to varying wood recycling rates. Note that all values, except the wood-based building ratio, are aggregated, incorporating previous values. Consequently, artifacts may appear in the initial 50 model iterations due to the amplified impact of minor influences. Aggregated reporting was used due to fluctuating material demand and demolition waste. The mismatch between material released during demolition and required material highlights the need for higher recovery and recycling rates and larger material stocks, especially with increased wood-based construction.

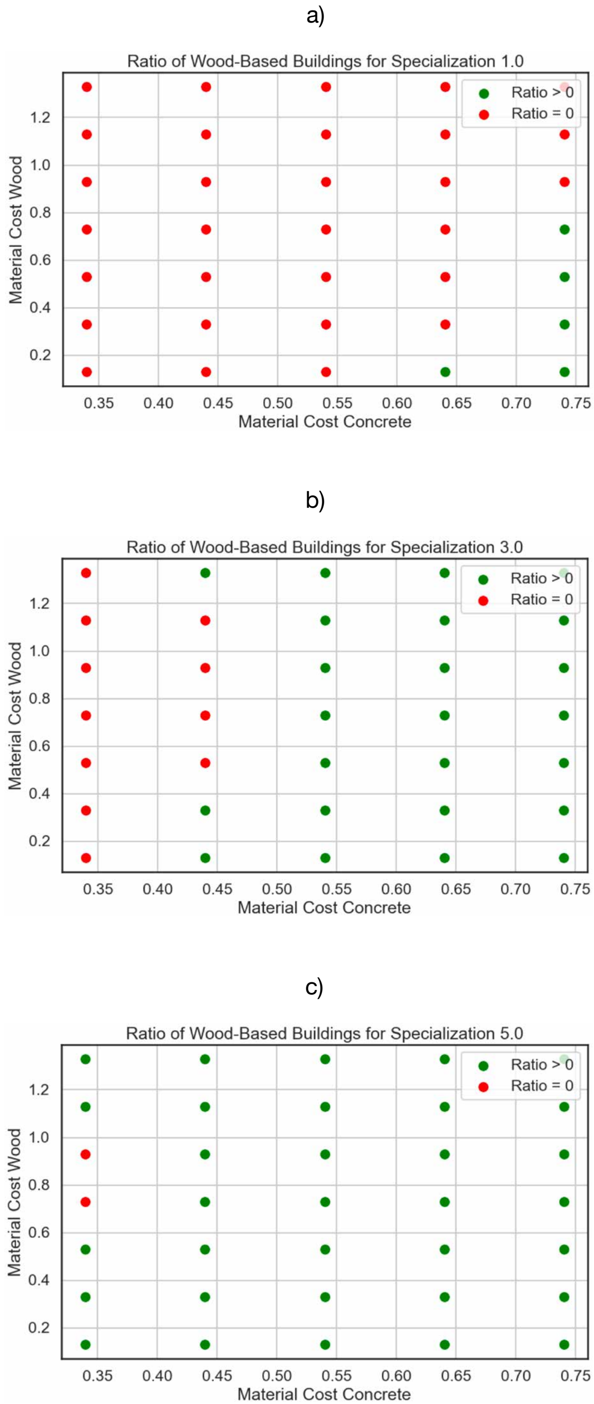

FIG. 6.5 Combination of a subsidy on mass timber and a taxation on reinforced concrete by Specialization: a=1, b=3, c=5.

Note: Green means that the final wood-based building ratio is non-zero.

Figure 6.6 indicates a rise in wooden material landfilling over time, contrasting with concrete, likely due to continued demand of concrete in wood-based construction, although the wood content in the built environment changes with the prevalence of wood-based buildings.

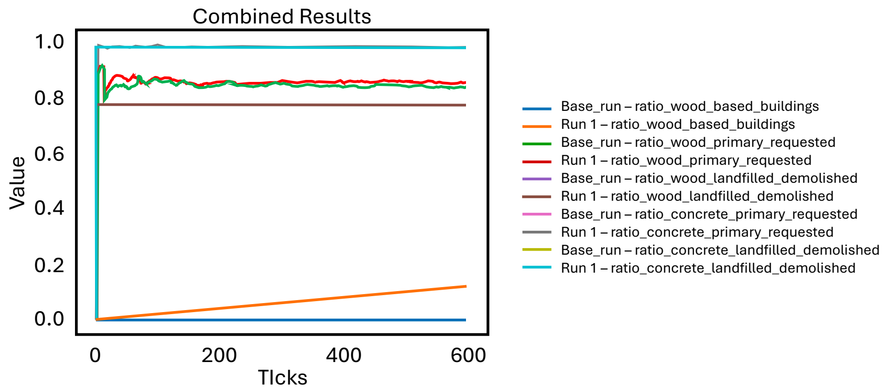

FIG. 6.6 Figure 6.6. Model runs with and without policy intervention

6.5 Discussion

Our findings are both expected and unexpected. Firstly, the 130 identified actions signal an increasing number of available tools to enable a transformation in the built environment of Amsterdam. It is worth noting the enabling role of the Municipality of Amsterdam in using its capacity to unveil authority instruments from existing laws and regulation in support of the city's circular economy transition through CircuLaw. In the presence of a vast set of instruments (N=80), it was expected to find all three types of instruments through the analysis. However, it was unexpected to find such a small number of economic instruments (16%) as in principle the circular economy seeks to transform a linear economic system into a circular one, and that only a third is active. Such a small share of economic instruments does not mean anything on its own, for a reduced number of instruments (as it is shown in this paper by a very limited test) can potentially have a considerable impact in changing practices in the construction and management of the built environment if they target the right system tweaks (Kupers, 2020). Yet, the instruments tested in this paper are not active and remain a proposal at the time of writing. These findings echo the state of the circular economy transition in the Netherlands proposed by Cramer (2022). Like she explains, The Netherlands can be characterised as one in a 'just before acceleration' phase, wherein (sub)national policies are in place and the involvement of local authorities is high but the circular economy still is not established.

Regarding circular city development, it was expected that looping actions would prevail over ecologically regenerative and adapting ones. This has been recently observed in circular built environment research both in theory (cf. Bucci Ancapi et al., 2022b) and in a Dutch case study (cf. Bucci Ancapi, 2023). This can be explained by understanding the long-standing development of the circular economy from waste treatment principles and application that have slowly moved up the R-Ladder (i.e., moving from landfilling to incineration and recycling) (Van den Berghe et al., 2020). It was also expected to find a match between looping and low-level circular strategies such as recycling instead of more transformative strategies (e.g., refuse, reduce) that could steer a more radical transformation of the way the built environment is built, managed and constrained, for instance, by actions that prioritise the conversion of existing building stock and alternative ways to building occupation. What is more, adapting actions mostly include sectoral measures that directly did not involve the participation of citizens and communities in the re-organisation of living and building in relation to the circular economy. The stated situation regarding timber construction and circular city development in Amsterdam echoes the findings of the Keblowski et al. (2020) who claim that the widely-shared, transformative premise of the circular economy seems to be merely discursive to date, while following prevailing capitalistic interests and giving agency to the usual incumbents in urban decision-making. This trend was also identified in Amsterdam by Calisto Friant et al. (2023) who point out that current circular city policies fail to address social, political and ecological implications of the circular transition in the Dutch capital.

Regarding the policy instruments simulation, it is clear that merely increasing the price of reinforced concrete or decreasing the price of mass timber does not yield consistent outcomes, largely due to the inertia within construction firms and building owners. This situation adds a new dimension to the observed slow uptake of mass timber construction covered in the introduction of this article and pointed out by Franzini et al. (2018) and Ghobadi and Sepasgozar (2023). At the model's outset, all architecture and construction companies specialise solely in masonry-based construction, resulting in a substantial premium for wood-based materials due to agents' unfamiliarity. This scenario applies to both private and public owners. Adjusting the cost of reinforced concrete alone requires a unit price far exceeding

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the reasonable upper bound material unit cost. However, this relationship is not universally applicable, as there are instances where combinations such as taxing reinforced concrete and subsidising mass timber prove effective, while in other cases, reducing mass timber's price fails to generate the desired impact. Merely altering material prices within reasonable bounds lacks consistency and robustness, with both policy instruments deemed insufficient for overcoming system inertia.

There is a clear correlation between taxing reinforced concrete and the proportion of wood-based buildings, as well as subsidising mass timber and the ratio of wood-based constructions. However, this correlation lacks robustness. Combining both policies offers more promising outcomes but requires a substantial reduction in mass timber prices and an increase in reinforced concrete prices. This points brings back the discussion over the resource base of timber in the Netherlands and more generally in Europe (Peng et al., 2023; World Resource Institute, 2023), also covered in the introduction, for the price of timber will depend on its availability in a European context marked by recent policy developments around the "Fit for 55" policy package. The latter does not include mass timber construction as a primary strategy nor provides certainties about the balance between timber availability, forestry expansion, and forest conservation and restoration (cf. EC, 2021).

Next to the cost discussion, it is important to highlight the unexpected finding regarding the unavoidable need of concrete in mass timber construction. While the potential of biobased construction has been assessed and found favourable in reducing CO2-eq emissions (Buchanan & Levine, 1999; Churkina et al., 2020; Himes & Busby, 2020), little attention has been given to the use of concrete in buildings foundations depending on building types, height, and function. The discussion on policy choices for building materials is often framed in terms of either timber or concrete or other non-biobased materials (UNEP, 2023). However, this research emphasises that timber construction still needs other non-biobased materials such as concrete. This ABS shows a large material intensity and amount of concrete being released after demolition, which can be re-integrated in the built environment if properly estimated and recycled. It is worth noting that urban mining research has been conducted in Amsterdam for types of metals, as a critical resource, in its built environment (AMS Institute, 2016; Koutamanis et al., 2018), yet a massively and locally available resource such as concrete to be reused or recycled is not included in the policy documents analysed for this study. Hence, policy choices regarding incentives to mass timber construction in Amsterdam should identify under which circumstances locally available re-used or recycled concrete should also be incentivised, for example by taking into account its spatial consequences (cf. Van den Berghe & Verhagen, 2021).

During the model analysis, a more effective policy approach emerged: adjusting the initial familiarity of architecture and construction companies with wood-based materials. The city of Amsterdam could facilitate knowledge sharing on wood-based construction practices, as agreed upon in the 'Green Deal Timber Construction', thus improving the effectiveness of (treasure) instruments. Architecture and construction companies play a pivotal role in the premium paid for wood-based construction, as their familiarity significantly influences construction costs. Competitive wood-based construction leads to varied specialisations among firms. However, not all companies venture into wood-based structures due to cost-effectiveness concerns, especially in certain building types where masonry remains favourable. Specialisation drives divergence, with masonry construction remaining crucial for specific projects. While policy actions can enhance specialisation and familiarity, in the long term, they may strain masonry construction. By disseminating knowledge within construction companies and their supply chains, the familiarity gap between wood-based and masonry-based construction can be minimised, leading to cost reductions. Thus, this article claims that by means of ex ante policy evaluation policymaking and future policy cycles regarding the adoption of mass timber construction in Amsterdam can yield more transformative results. After all, the achievement of policy goals highly depends on the adequate selection of policy options (Bemelmans-Videc, 2003), and the identification and activation of specific systemic tweaks with transformative power within the existing policy structure have greater effectiveness compared to setting up of overall new policy structures (Colander & Kupers, 2014; Kupers, 2020).

The analysis and ABS, however, faced several limitations and can be improved in certain directions. Firstly, the analysis included only local, regional, and national policies. Undoubtedly, the inclusion of European-level policies can yield more comprehensive insights regarding policy instruments for the adoption of mass timber construction. Secondly, data regarding material intensities of timber could be improved by building up a repository based on the Dutch context. Thirdly, an important model limitation is the lack of data on concrete and timber released during building adaptation and renovation processes as well as about the quality of the released materials, which could be obtained by estimating an average material intensity. Fourthly, the model could also be improved by adding a Geographical Information System (GIS)-based visual representation of the built environment, as well as an estimation of CO2-eq emissions resulting from material transport throughout Amsterdam. Finally, our findings resulted from using only three policy instruments, of which only one (i.e. demolition notification) is in place in Amsterdam. This decision followed the desire to test economic instruments as the circular economy aims to change the current economic system, however, the results of our model remain speculative.

In addition, it is worth discussing the analytical concepts used in this article, namely policy actions, instruments, coherence and ex-ante evaluation. This is one of the first articles to focus on policy actions as an umbrella term for more or less defined instruments. This decision was made in order to include a wider range of policy options in an early sustainability transition, but most policy actions that have not been implemented through a concrete policy instrument remain open for scrutiny and lip service in the meantime. Various typologies of policy instruments exist, but this article has drawn on that of Vedung (1998), which is notable for its simplicity and clarity. It may be argued that this typology does not capture all the mechanisms through which governments effect change; this is true. It might be interesting to explore other typologies, such as that of Hood and Margetts (2007), which also includes a typology (i.e. organisation) that reflects government capacity and the own resources it can use to effect change, for example by simplifying approval procedures or providing physical space. Finally, the use of policy coherence and ex-ante evaluation was intended to suggest a way of analysing circular city policies during policy formulation or early stages of implementation. They can by no means be used to assess the overall effectiveness of policy decisions; the use of ex-post evaluation remains necessary to assess policy effectiveness. These improvements could further validate the proposed ex ante analysis and ABS as tool for policymakers in circular city policy formulation.

6.6 Conclusion

The aim of this article was to evaluate policy actions for timber construction by means of *ex* ante policy evaluation. The case of Amsterdam was selected given recent policy developments regarding circular economy and mass timber construction, making it a particular case. This article found a total of 130 policy actions and 80 policy instruments amongst those actions. Next to this, a prevailing focus on looping and substituting actions over ecologically regenerative and adapting ones was also identified, echoing previous findings that characterize circular built environment policies as building upon a long-standing waste management principles aiming to shift from landfilling to incineration and recycling. The model and resulting simulation highlights the potential transformative power of economic instruments paired with improvements in capacities around mass timber construction practices, as well as the unavoidable role of (recycled) concrete in supporting a more circular and biobased built environment in Amsterdam. In conclusion, this article supports the usefulness of ex ante policy analysis as tools for policymaking regarding the transition to a more circular built environment in Amsterdam and possibly elsewhere. This research direction can benefit from (i) expanding ex ante policy analysis to supranational policies, (ii) the gathering and structuring of data in relation to material intensities of building renovation and adaptation, (iii) integrating Geographic Information Systems to the model for the estimation of carbon emissions in material transport, (iv) further improving the visualization of simulation to better inform policymaking processes and future policy cycles, and (v) combining this analysis with an study of the politics and polity around (mass timber) construction to explain how policy actions for mass timber construction are decided and designed.

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7 Conclusion

As this dissertation comes to an end, it is a scientific imperative to draw conclusions, reflect on the research contributions, limitations and future research directions that are proposed to further extend and enrich the knowledge of circular built environment policies and their contribution to circular city policy making. This chapter begins by drawing conclusions in relation to the research questions posed in Chapter 1, followed by the scientific and societal contribution of this dissertation, a reflection on the main limitations of this research, and an agenda for future research.

7.1 Answers to the research questions

7.1.1 What is a circular built environment?

In this dissertation, the built environment has been used to approach the circular city. From a construction management perspective on the built environment, where a circular built environment is achieved by introducing circular economy strategies in the construction and operation of the built environment, this dissertation proposes a perspective that looks at the built environment as an enabling element of circular cities in relation to other urban policies.

Different spatial scales can be identified in the built environment, ranging from fine-grained levels such as materials and components to broader scales such as neighbourhoods, cities and the global level. Circularity, defined as the closing of material and energy loops with minimal environmental impact, is more easily applied at lower scales, such as buildings, where the reuse of materials and components is logical. However, the understanding of circular *economy* is more naturally aligned with higher scales, such as nations or the global level, where it encompasses the broader economic systems, institutions and (im)material flows that enable production and consumption. In essence, a circular city or region cannot exist without both a circular built environment and a circular economy that integrates people, institutions and materials. Put another way, a circular built environment is an enabling element for the functioning of a circular city. A circular built environment is part of a complex adaptive system that cannot be understood by the sum of its parts (i.e. buildings and infrastructure, supply chains) but by the emergent properties it enables (Bucci Ancapi et al., 2022a). This dissertation therefore positions that the current understanding of a circular built environment does not see the *city* for the *buildings* (cf. Chapters 4, 5 and 6). It is therefore not surprising that current circular economy policies for the built environment are to some extent lacking in ecological regeneration and adaptation measures. After all, ecological regeneration and adaptation of urban communities are not common elements of policy interventions in construction supply chains. Nonetheless, it was interesting for this dissertation to examine the extent to which these aspects of circular city development were present in the case studies.

Current circular built environment policies that do not approach the built environment from a circular city development perspective are by no means unnecessary, irrelevant or incoherent. The scale and complexity of the built environment requires changes in supply and value chains to clearly enable a transition to more circular resource use and management. In the cases of Delft University of Technology, Amsterdam, and Greater London, policy coherence has improved throughout the years. It is clear that these urban areas have moved from initial strategic vision documents, to more or less defined sets of objectives and instruments for more circular resource management in construction.

7.1.2 What is the current understanding of the relationship between a circular built environment and policy instruments needed to bring about a circular built environment?

This research question was answered by answering three sub-questions, namely 1) how many publications discuss circular built environment policy instruments; 2) what types of circular actions are mentioned in relation to circular city development; and 3) what policy instruments are proposed to implement a circular built environment. The results were as follows: First, an analysis of 166 publications from 2010 to 2020 revealed an increasing focus on policy-related topics within the circular built environment, suggesting that the transition to circularity is increasingly linked to policy development efforts. This trend is seen as a positive indicator for the advancement of circular built environment practices. Second, when categorising the types of circular actions discussed in these publications, following Williams (2021)'s circular city development framework, the majority focused on circular actions such as recycling, reuse and recovery. These actions often build on existing transitions in

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energy and waste management, particularly in Europe and Asia, which were the most represented regions in the sample. However, actions related to ecological regeneration and adaptation received significantly less attention, indicating a gap in the holistic development of circular cities. This imbalance highlights a technocratic bias in current research, with an emphasis on technical processes rather than broader ecological and adaptive strategies. Finally, the study found that regulatory policy instruments were the most frequently cited, outpacing other types such as financial incentives, provision and capacity building measures. This prevalence of regulatory approaches suggests that circular city development is still in its early stages and that more diverse and mature policy instruments are needed to support widespread implementation.

7.1.3 What is the potential of combining existing frameworks for circular city development and policy coherence in informing policymaking?

This dissertation highlights the potential of combining existing frameworks analysing policy coherence with frameworks analysing circular city development to uncover blind spots in circular built environment policies. The advantage of analysing policy coherence in the context of circular city development is that it allows the analysis of both process (policy making) and content (circular city development). This combined framework improves the coherence of circular built environment policies by integrating substantive analysis into a typically process-based approach. It helps to address some of the shortcomings in policy formulation identified in the literature, as well as fundamental limitations in policy coherence, such as that of setting system boundaries for analysis.

In addition, this coherence analysis framework has the potential to serve as an ex ante policy evaluation tool, supporting early policy formulation by identifying opportunities to integrate different circular actions, such as combining looping actions with ecological regeneration, to create a more holistic, nature-inclusive built environment. Policymakers can use this framework to develop more ambitious and balanced policies, identifying opportunities for improvement of current policy targets and instruments or the introduction of new ones. Different stakeholders can also benefit from this framework: researchers can use it to study the governance of circular urban systems, evaluators can develop more comprehensive Key Performance Indicators (KPIs) and evaluation frameworks, and city or campus staff can use it in planning or mid-term evaluations to drive more effective circular change. Circular city practitioners will gain a clearer understanding of policy progress, tool status and implementation expectations.

7.1.4 How coherent are circular built environment policies?

The answer to this question is that while circular built environment policies have improved their overall coherence, particularly through business-led optimisations in construction practices, they fall short of fully realising a circular city as envisioned by the circular city policy coherence framework. Urbanisation, together with the construction and operation of the built environment, is a major contributor to the ongoing socio-environmental crisis and requires drastic and radical changes for a more resource-efficient and resilient future. Policies in Greater London and Amsterdam effectively highlight critical issues such as resource depletion, waste generation and potential strategies to mitigate these unsustainable trends. However, they lack a deeper, systemic engagement with broader issues such as the need for new construction, the maintenance and adaptive reuse of existing buildings, and the active involvement and adaptation of residents and communities in circular urban development. These aspects are essential for promoting circular and sustainable urban environments, but are largely overlooked in current policy approaches.

When it comes to making circular city policies more concrete, one might ask: is it essential for cities to have an overarching circular city policy? Could circular city policies be included in different policy domains and still be coherent? This dissertation argues that it is not necessarily important to develop a policy domain around circular city development, if different policy domains include looping, ecological regeneration and adaptation actions, and if they can be aligned and implemented in a coordinated way. The OECD (2020) recommends the development of a strategic vision to kick-start the transition in cities and regions, as it can provide a strong political signal of what can be expected in the future, bring relevant stakeholders together, identify preliminary lines of action and mechanisms needed for the transition, such as policy targets and instruments, and limit persistent siloes in policymaking. While the development of circular city development as a distinct policy domain may bring these benefits, this dissertation shows through the case of Greater London that the lack of ecological generation and adaptation actions in circular economy policies can be addressed through instruments such as the London Plan (as stated in section 5.5. it is recommended to find synergies between the Urban Greening Factor and other policy requirements in Greater London when calculating it), a planning instrument.

7.1.5 How can policy coherence help to enhance the effectiveness of circular built environment policies?

Policy coherence can enhance the effectiveness of circular built environment policies by allowing a more comprehensive evaluation of policies before and during their implementation. Policy coherence proved useful in the cases of Greater London and Amsterdam to point out blind spots in the way a circular built environment serves the policy aim of a circular city. It also shed light on the alignment of policy objectives, instruments, and implementation measures. In the case of Amsterdam's policy on mass timber construction, ex ante policy evaluation by means of circular city policy coherence analysis identified 130 policy actions and 80 associated instruments, revealing a predominant focus on looping and substitution actions over ecologically regenerative and adaptive ones. This pattern is consistent with previous observations that circular built environment policies often build on traditional waste management principles, emphasising shifts from landfill to incineration and recycling. The agent-based simulation (ABS) developed and run for this dissertation underscored the transformative potential of economic instruments when combined with increased capacity in mass timber construction, as well as the critical role of recycled concrete in supporting circular and bio-based construction. In the case of Greater London, this dissertation identified a similar trend regarding the focus on looping and substitution actions in circular built environment policy. Potential synergies were identified in the combination of two policy instruments, namely the Urban Greening Factor and the Circular Economy Statement, to foster the integration of ecologically regenerative actions in the built environment. However, as the Circular Economy Statement works based on assumptions of future circular design and operation of buildings, its evaluation remains highly subjective and its outcomes unchecked to date.

Ultimately, the findings suggest that ex ante policy evaluation by means of policy coherence analysis can guide more effective policy-making in the transition to a circular built environment, both in Amsterdam and in other European cities.

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7.1.6 To what extent do circular built environment policies contribute to policy ambitions as formulated by cities?

In short, and as a key message of this dissertation, the circular built environment policies analysed in this dissertation have consistently increased their coherence through business-driven optimisations in construction practices, but less so in enabling a circular city. The circular built environment policies in London and Amsterdam have been formulated in such a way that they effectively draw increasing attention to issues of resource depletion, waste generation and potential strategies to address these unsustainable trends. However, following Ness (2022), a deeper and more systemic consideration of the need for new buildings, the maintenance and adaptation of the existing building stock, and the involvement and adaptation of residents and communities in circular city development remains largely unconsidered in the policies selected throughout this dissertation.

As the gap in this dissertation is that of *coherence* in circular built environment policy, it is worth considering whether the gap is relevant and worthy of further exploration beyond this research project. On the issue of coherence in policy formulation and implementation, May et al. (2006) rightly point out that more coherent policy is not necessarily better policy. If policies are well structured in terms of objectives and instruments for their implementation, but are not appropriate to the policy problem at hand, coherent policies may still be largely ineffective. May et al. (2006) go on to criticise the idea that many policy scholars have of the desirability of policy coherence by citing the example of dictators who may appear to be quite coherent in their policies and yet be judged by the undesirability of their policy choices. That is, there is no intrinsic value in policies being more coherent if they fail to address the very issue they are trying to respond to, or are simply framed by inadequate reasoning. In the context of this dissertation, the apparent increase of coherence of circular economy policies and the lack of coherence for circular city ones for the built environment seems to be an inevitable characteristic of coherence in pluralist political systems such as in the Netherlands and the United Kingdom. According to Carbone (2008), coherence ultimately depends on the perspective of the observer (e.g. a policy may appear coherent from a trade perspective and less so from a development perspective). It is worth recalling that policy- and decision-making in the built environment involves a complex multi-level process in which stakeholders normally have conflicting interests, operate in different markets and within different physical and administrative limits (Head, 2022; van Bueren & De Jong, 2007; van Bueren & Priemus, 2002).

To be valuable, coherence requires appropriate framing; this is what this dissertation tried to provide. Science, in its ever-growing interest in explaining the phenomena that creates the world we live in, is a powerful tool to guide evidence-based policy formulation. Through different perspectives, techniques and the compilation of replicable findings by the scientific community, science can provide framing conditions to policy issues; this is what this dissertation proposed to fill the gap of coherence in circular built environment policy. By sustaining a perspective of circularity in the built environment based on the concept of *circular cities*, policy coherence analyses included in this dissertation show that what has been meant to foster economic growth and eco-accumulation of capital (cf. Savini, 2023) is not suitable to conceptualise urban policy issues in relation to circularity, the choice of policy responses and the subsequent formulation of policy objectives and instruments. The OECD *The Circular Economy in Cities and Region: Synthesis report* arguably coincides with this conclusion. In the report, policy coherence is widely discussed as a facilitator for the circular economy transition, by fostering system thinking in order to i) identify synergies across different policies and plans, ii) strengthen co-ordination across policies and governmental departments, and iii) introduce adjustments throughout the policy cycle (OECD, 2020, p. 140). Notoriously, coherence was identified as a key challenge in different European cities and regions, such as in Tallinn (Estonia) (OECD, 2023), Zuid-Holland (the Netherlands) (OECD, 2024b), and the Eurométropole of Strasbourg (France) (OECD, 2024a).

7.2 Contributions and policy recommendations

7.2.1 Contributions to knowledge

The problematisation of circular built environment policies in relation to circular cities is the main contribution of this dissertation. The analysis of policy objectives and instruments of circular built environment policies in London and Amsterdam is, to the author's knowledge, the first of its kind. This was possible through a series of steps that are reflected in the sub-research aims of this dissertation.

Firstly, without proposing a concrete definition of a circular built environment, this dissertation positions a circular built environment as an enabling element of circular cities. This perspective offers an alternative to prevailing approaches to the circular built environment based on supply chain and the integration of circular economy strategies into such chains. Cities, as complex adaptive systems, create the built environment as an emergent property of themselves. As discussed in Chapter 3, the built environment has artefactual complexity (it becomes complex through human action and agency). Put another way, the built environment will only be what people want it to be. This means that policy decisions regarding the development of the (circular) built environment will shape it one way or another, more or less in line with the circular city objective that policy makers in cities have envisioned for the city.

Secondly, this dissertation provides the first systematic literature review of policy instruments for a circular built environment from a circular city development perspective. The review highlights the technocratic tendency of most policy instruments discussed in the academic literature and the predominant focus on looping measures (i.e. recovery and recycling). The identification and listing of regulatory instruments (e.g. regulations, standards) as the main type of policy instruments proposed to concretise a circular built environment is another contribution of this dissertation.

Third, and perhaps most importantly, this dissertation provides an ex-ante policy evaluation framework for circular cities, which has been tested with an urban development proxy and validated using circular built environment policies in different European cities (i.e. Amsterdam and London) as case studies. This evaluation framework is the only one to date (at least as far as the author is aware at the time of writing) that not only provides a combination of process and content elements in circular city policy, but also allows for the analysis of policy alignment and synergies between different policy areas in cities. In addition, in the case of Amsterdam, the ex-ante evaluation framework was complemented by an ABS to visualise the complex interactions and emergent properties of different policy instruments. Although not predictive, the combination of policy coherence analysis and ABS in ex-ante policy evaluation could help circular city and built environment researchers to understand the potential impact of specific policy formulations in implementation processes and policy evaluation.

7.2.2 Contributions to society

The circular city policy coherence framework offers societal and practical contributions and could have the potential to become a useful ex ante policy evaluation tool. By identifying the (mis)alignment between the policy areas that interact for a circular built environment, as well as the opportunities for integration, such as combining circular actions with environmental regeneration and adaptation actions, it can improve early policy making processes to support a circular built environment that effectively contributes to policy ambitions as formulated by cities.

Policy makers could use this framework to develop more ambitious and balanced policies that include all three circularity actions, with policy coherence factors providing the justification needed to refine current policy objectives and instruments, or to propose new ones for implementation. Policymakers could also use this framework to draw attention to policy blind spots or gaps and to motivate the involvement and coordination of intra-governmental departments. It is worth noting that coordination and policy coherence have been recognised as key challenges in the transition of European circular cities and regions (OECD, 2020).

Several urban actors could benefit significantly from the circular city policy coherence framework. Circular city researchers gain an analytical lens to explore the governance of circular urban systems through evidence-based policy analysis of established or proposed policy objectives and instruments. Evaluators in the built environment can develop more comprehensive key performance indicators (KPIs) and evaluation frameworks aligned with circular city development. City government staff can use the framework in both early planning stages and mid-term evaluations to drive more comprehensive and effective circular built environment policies. City staff can also use the framework to propose measures to improve the effectiveness of circular built environment policies, explore synergies across urban policy domains (e.g. built environment and nutrition, built environment and transport, biodiversity and food in a circular city), bring actors together to collaborate in solving identified misalignments. Circular city practitioners can gain a better understanding of policy objectives, the status of policy instruments and what is expected to be implemented, as well as to evaluate their own performance in relation to policy goals and instruments in place. Last but not least, citizen and non-governmental organisations could use the framework to push policy-makers towards more ambitious policy responses in relation to circularity in the built environment and city development.

A survey conducted by the OECD (2020) Programme on the Circular Economy in Cities and Regions identified that the main obstacles faced by European urban and regional governments in the transition towards the circular economy are related to governance issues[18] such as insufficient resources, inadequate regulatory frameworks and incoherent regulation across levels of government, among others. The OECD survey also pointed out the main policy gaps, namely a lack of holistic vision and of political will. Incoherence across levels of government and a lack of holistic visions in the transition were of special interest for this dissertation.

The obstacle and gap identified above give a hint into capacities that city governments need to develop to effect a more transformative transition: policy coherence analysis to bridge policy siloes and improve coordination among policy domains and actors. Developing this capacity has been highlighted as a pressing governance need in different European case studies, namely the Province of Zuid-Holland (the Netherlands) (OECD, 2024b), the Eurométropole of Strasbourg (France) (OECD, 2024a), region of Møre and Romsdal (Norway) (OECD, forthcoming-b) and Berlin (Germany) (OECD, forthcoming-a). The circular city policy coherence frameworks can help policymakers in cities to build this capacity as a discussion kickstart or as a more elaborated analysis towards improved policy choices and effect.

18 Interestingly, the lack of technical solutions (e.g. technologies) were the lowest ranked obstacle.

7.2.3 Policy recommendations

As this dissertation has focused on the circular built environment as part of circular city policy, some simple but concrete recommendations can be made specifically for the formulation of these policies.

Firstly, policymakers could make the built environment work for circular cities. As shown throughout this dissertation, circular built environment policies have increased their coherence consistently by means of a plethora of looping actions, business development support, stakeholder engagement and more or less the integration of ecologically-regenerative and adaption actions. The progress made in fostering a circular economy in the built environment can serve as inspiration to foster a built environment that works for a circular city as well. This would require working with urban communities (e.g. neighbourhoods, civil organisation, businesses, academia, public authorities in charge of different sectoral policies) , finding ways by which circular economy strategies in the built environment can also work to reduce the impact of urbanisation over natural ecosystems, the restoration of ecosystems by means of urban ecosystem services provision and the integration of green and blue infrastructure to enhance the resilience of the urban environment. This will in turn contribute to what has been referred to as 'a functional scale' for the circular economy in cities and regions (cf. OECD, 2020), which comprises the territorialisation of the circular economy and closing, narrowing, slowing and regenerating cycles of materials and energy in urban areas.

Secondly, policymakers should explore (and where possible integrate) the question of sufficiency and how to build less (Ness, 2022). As actors in the circular built environment have often said: *"the most circular building is the one that does not need to be built"*, or something similar. This phrase, or the reference to this idea, was not found in any of the policy documents analysed for the purposes of this thesis. In some ways this makes sense, as addressing the issue of sufficiency by building less ultimately means redistributing and renovating the building stock. Most if not all cities and regions in Europe see opportunities for economic growth and development in building more, and this is the opposite of the idea of sufficiency. However, the circular economy in European cities is currently characterised by low-potential circular economy strategies in place (i.e. energy recovery through incineration and recycling) (cf. Cramer, 2022; Van den Berghe et al., 2020), which can be understood as a lock-in that prevents higher-potential circular economy strategies such as reduce, refuse, and reuse to be the new normal in the built environment. After all, the highest circular strategies are *re-think* and *refuse*, which hold the most transformative potential towards circularity.

Third, circular built environment policies should be assessed by the transformative power of policy instruments, not just the agreement on policy goals. "Circular washing" is a reality; most cities and countries would claim to be circular immediately after launching a circular economy strategy or roadmap. While strategies and roadmaps are important because they are usually agreed by a number of actors, mobilise governments towards a more defined goal and serve as a political signal to societal actors and markets about what to expect in the future, they may not trigger substantial change on their own (OECD, 2020). In the two case studies included in this thesis, the state of policy instruments for a circular built environment was a concern. In the case of Greater London, where a policy instrument was specifically developed to integrate circular economy strategies in construction (i.e. the Circular Economy Statement), there was no information available at the time of research on the impact of the instrument or on the adoption of the instruments by local authorities. In the case of Amsterdam, the city has made efforts to reinterpret current policy instruments for construction and urban development to work for the circular economy and has established a Green Deal for timber construction, but there is no data on how the reinterpretation of these policies and the policy measures included in the Green Deal Timber Construction can work effectively and synergistically to make a circular city a reality.

Fourthly, integrating circular economy actions into spatial planning may be an effective way to integrate circularity into urban development and to create synergies between looping, ecological regeneration and adaptation actions. Spatial planning policy typically provides the process and tools that could help to bring these three actions together in the planning, design, construction and management of the built environment. Although regulatory powers and responsibilities vary across countries depending on governance structures (e.g. centralised, federal, or decentralised), at least in the three cases studies included in this dissertation, local governments have powers to regulate the allocation of land, and the design, materiality and norms of construction. What is more, local authorities are more aware of their territorial context than national legislators or policymakers, which entails that they can fine-tune the use of spatial planning instruments to specific local needs and experiment with them to achieve the development of a circular city.

7.3 Limitations and agenda for future research

It is a scientific imperative to reflect about the limitations faced during the production of this dissertation in pursuit of transparency and scientific integrity. As any research project, this dissertation faced several limitations. These are supplemented with an agenda for future research, which contains proposals to enhance the scientific inquiries in relation to circular built environment policy, develop it further and point out future scientific directions that may be of interest of the scientific community.

7.3.1 Reflections on Methods and Data limitations

The development of a framework for the analysis of coherence in circular built environment policy was not exempted of difficulties. These difficulties can be divided into methodological and contextual.

Methodologically, policy coherence is a concept difficult to operationalise for there is the issue of framing: what policies should cohere? As policies are not created in a vacuum for they normally build upon past policies (e.g. the circular economy has mostly been developed as an expansion of waste management management) and they interact with different policy domains (e.g. the circular economy in the construction sector can link forestry, environmental, trade and building policies, among others). To address this issue to some extent, this dissertation only included circular economy policies explicitly referred as such. This is to say, policies that build upon waste management were not included in any of the analyses. The decision to consider only circular economy policy documents was taken for framing purposes. As described by May (2005) on the pitfalls of policy coherence analysis, one of the main analytical difficulties is setting boundaries for the analysis of policies that should in principle be coherent. Setting the boundary around policies explicitly developed for the circular economy was therefore chosen as a way of delimiting the analysis. This proved useful from an early stage in the process of writing this dissertation, for example in delimiting the scope of the systematic literature review. Later on, given that the TU Delft, London and Amsterdam cases each have a decade of circular economy policy development (on their own or as reflected in national level documents), this decision allowed for the analysis of a medium to long-term policy area such as the circular economy on its own. However, the decision to restrict policy analysis to policy documents also posed limitations. Prevailing epistemological perspectives frame policy as a continuum expressed as the so-called policy cycle. The policy cycle is divided into five concatenated steps, namely: agenda-setting, policy formulation, decision-making, policy implementation, and policy evaluation (Howlett et al., 2020). This dissertation dealt only with the policy formulation and evaluation steps. This decision was beneficial for the research project, as it made it manageable during the four years of this project (2020-2024). It also allowed a better scientific output as policy coherence analysis based on policy document analysis can be easily replicated and scrutinised if necessary.

This dissertation only indirectly provides insights about the politics (i.e. actors and their resources) and polity (i.e. political structures) involved in the development of circular built environment policy. As this dissertation followed Lange et al. (2013) in their distinction between politics, polity and policy as foundational pillar of governance as a means for the collective achievement of collective goals, two pillars were not included in this dissertation; without them, the study of circular city and built environment governance remains vastly unexplored. Currently, the OECD is conducting case studies on the circular economy of European cities and regions (e.g. OECD, 2017, 2023, 2024a, 2024b) including these three pillars, but also only indirectly.

In relation to the literature reviews conducted for this research project, the limitations can be summarised in 5 aspects. Firstly, a keyword-matching literature review has the pitfall of missing relevant publications and perspectives, especially in emerging fields such as circular economy and circular cities. Second, the systematic literature review in chapter 3 was conducted using the PRISMA guidelines, which were developed for medical science. Although their use is becoming common practice in the social sciences, the systematic part of the literature review is limited to the scoping, identification and inclusion of documents; the revision is entirely dependent on the researcher's perception and may therefore produce results that are less reliable and replicable. Thirdly, although widely used policy terms and major databases such as Scopus and Web of Science were used to ensure diverse and indexed sources, only scientific literature (i.e. scientific articles and book chapters) was included in chapters 2 and 3. This decision excluded the contribution of policy documents from public and private sources from the analysis. Fourthly, it was decided to include only publications written in English. Finally, the built environment has been studied in this thesis only from an urban perspective, leaving out its rural dimension.

Chapter 6 included the development of an ABM of the built environment in Amsterdam for the analysis of the effect of selected policy instruments in stimulating mass timber construction as circular economy strategy. The analysis and model have several limitations that can be addressed to improve their representation of reality in Amsterdam and overall scientific output. Firstly, only local, regional and national policies were included, leaving out European-level policies that could provide a more comprehensive understanding of policy instruments for the adoption of mass timber construction. Secondly, data on wood material intensities could be improved by creating a repository specific to the Dutch context. Thirdly, the model lacks data on concrete and wood released during building adaptations and renovations, which could be estimated using average material intensities. In addition, the inclusion of a GIS-based visual representation of the built environment and the estimation of CO2-eq emissions from material transport in Amsterdam would further refine the model. These improvements would enhance the ex-ante analysis and visualisation, making the ABM a more effective tool for policy makers.

Contextually, this Ph.D. project started in March 2020, when the COVID restrictions were imposed in the Netherlands and worldwide. The pandemic affected almost every research project worldwide and imposed additional restrictions to those common to every Ph.D. project, namely time constraints, availability and reliability of data and methods, availability of software and hardware, and the personal circumstances of the researcher, among others. In scientific publications, it has become quite common not to accept reflections on the complications faced during a project; more and more scientific publications tell stories of 'straightforward success' from posing a research question, explaining the methods, presenting the results and reflecting on their significance and context in the scientific field. This dissertation faced all of the above limitations. Initially, the idea was to conduct a comparative study between the Netherlands and Chile in terms of circular built environment policies. There was also the idea of using Chile's transition to a circular built environment as a case study. The uncertainties that characterised the COVID pandemic ultimately limited the possibilities to what was available: to study the Delft University of Technology campus, to take advantage of the Dutch government's less restrictive commuting measures and use Amsterdam as a case study, and, once the border restrictions were over, to use the well-established links between Delft University of Technology and University College London to conduct a third case study in London. As scientific manuscripts are published independently of the doctoral thesis, it is not always possible to reflect openly on the choices researchers have to make in order to ensure that their doctoral projects are completed within the four years set as the time frame for completion in the Netherlands. This means that the value of research should not only be calculated on the basis of grandiloquent results and research outputs; the value of research should rescue what back in time was a normal practice and ensure that the context of the research(er) is also taken into account.

7.3.2 Directions for future research

Future research on policy coherence for circular cities and the built environment should prioritise several critical areas, as discussed in chapters 3, 4, 5 and 6. First, it would be beneficial to link the concept of policy coherence to other important concepts in policy analysis, such as policy integration, interplay and mix (cf. Huttunen et al., 2014). There is also an urgent need to identify and integrate missing dimensions into existing circular city development frameworks, drawing on interdisciplinary perspectives from urban planning, environmental and social sciences to ensure a holistic approach.

Strengthening evidence-based policy making is another key area of focus. This can be achieved through collaborative projects that bridge the gap between academic research and policy practice, as well as through *ex post* evaluations of the circular built environment policies of London and Amsterdam to understand their effectiveness, limitations and whether a circular city policy coherence analysis is useful in improving the effectiveness of such policies. In addition, in-depth case studies of Dutch and British cities and other international examples will help to validate and generalise the findings of this dissertation.

Exploring the effectiveness of different policy instruments and policy mixes is essential in sustainability transitions (Rogge & Reichardt, 2016), such as to a circular city. This includes analysing current policy instruments, such as subsidies, taxes and updated regulations, and experimenting with new policy instruments to determine their impact on promoting circularity. Expanding the circular city policy coherence framework to include other urban dimensions of food production, mobility and ecological remediation and conservation, is also essential, as these areas are integral to the sustainability of urban environments. Spatial analysis and pilot projects can provide practical insights into how to effectively integrate these elements.

In addition, examining the role of political power dynamics in the design and implementation of circular built environment policies is crucial to understanding their policy implications in sustainable urbanization and urban metabolism (cf. Kaika, 2005; Savini, 2019). Political economy analyses and case studies focusing on power relations can shed light on how these dynamics influence policy outcomes and help identify ways to ensure more equitable and inclusive policy frameworks (Wachsmuth, 2012). As expressed in various parts of this thesis, the transformative power of circularity remains a doubt, as well as its potential to move beyond neoliberal urbanism and create the right governance structures to create spaces for much-needed socio-ecological transformation to sustain humanity in the long term (Bassens et al., 2020; Colander & Kupers, 2014).

Finally, the development and assessment of future scenarios could allow researchers to explore the potential impact of different policy directions in addressing the socio-environmental crisis. Scenario planning, modelling (for instance through ABS) and perception studies with actors from city governments, local businesses, academia and citizen organisations can provide a forward-looking perspective and enable the development of more comprehensive and resilient sustainability frameworks. Through these multifaceted research efforts, researchers in the field of circular cities, circular economy, sustainability transitions and urban governance may better understand and enhance the policy coherence needed to transition to more circular and sustainable urban environments.

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Appendices

Appendix I

TABLE APP.I.1 Inventory of circular built environment policies

Objectives	Instruments	References
1. To reduce the intake of primary resources	A New Sustainable Built Environment Strategy	EU Circular Economy Action Plan
	A Transition Agenda	NL Transition Agenda Circular Building Economy
	Annual implementation plan	NL Towards a Circular Building Economy
	Reduce resource demand	CRE-01
	Energy efficiency	CRE-01
	New Stepped Strategy	Sustainable TU Delft Vision, Ambition and Action Plan
2. To substitute unsustainably-sourced resources by sustainably produced ones.	Locally-produced renewable sources of energy	CRE-01
	Carbon pricing in supplier contracts, new construction projects, campus greening.	Sustainable TU Delft Vision, Ambition and Action Plan
	Carbon tax	Sustainable TU Delft Vision, Ambition and Action Plan
3. To develop new design and production processes to promote new ways of consumption.	An approach to reduce CO2 emissions in the construction industry	NL Transition Agenda Circular Building Economy
	Innovative products and services for circular construction	NL Towards a Circular Building Economy
	Incentives for R&D, experiments, prototypes and concrete projects	NL Towards a Circular Building Economy
	Flexibility and adaptability of new buildings	CRE-01
4. To reuse secondary resources (waste flows)	Material recovery targets	EU Circular Economy Action Plan
	Reuse of materials and energy flows	CRE-01
	Key Performance Indicators for circular use of materials	CRE-01
	Guidelines (6 rules) for circular demolition and material reuse	CRE-03
	New Stepped Strategy	Sustainable TU Delft Vision, Ambition and Action Plan

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TABLE APP.I.1 Inventory of circular built environment policies

Objectives	Instruments	References
5. Measurement and reporting	Development of a uniform measuring method for circularity	NL Transition Agenda Circular Building Economy
	Digital logbooks for buildings	EU Circular Economy Action Plan
	Common language and tools to define and measure circularity in projects	NL Towards a Circular Building Economy
	BREEAM certificate	CRE-01 Sustainable TU Delft Vision, Ambition and Action Plan
	MPG certificate	Sustainable TU Delft Vision, Ambition and Action Plan
	Key Performance Indicators for circular use of materials	CRE-01 Sustainable TU Delft Vision, Ambition and Action Plan
	Integrated Sustainability Report	Sustainable TU Delft Vision, Ambition and Action Plan
6. Market development for secondary resources	All governmental procurement circular by 2030	NL Transition Agenda Circular Building Economy
	Subsidy for circular business and earning models	NL Transition Agenda Circular Building Economy
	Sustainable finance framework and public procurement that integrates Life Cycle Assessment	EU Circular Economy Action Plan
	Concrete demand for circular products and services	NL Towards a Circular Building Economy
7. Policy, legislation, and regulation	Compulsory material passport by 2020	NL Transition Agenda Circular Building Economy
	Incorporate circularity into governmental standards for construction	NL Transition Agenda Circular Building Economy
	New construction product regulation	EU Circular Economy Action Plan
	Stimulating laws and regulations	NL Towards a Circular Building Economy
	Circular budget	CRE-04
8. Knowledge and awareness	Circular building as integral part of education by 2021	NL Transition Agenda Circular Building Economy
	Setting up a knowledge institute for circular construction	NL Transition Agenda Circular Building Economy
	Setting up awareness campaigns on circular construction	NL Transition Agenda Circular Building Economy
	Precise knowledge and action plan to halve emissions in construction	NL Towards a Circular Building Economy
	Living Labs	TU Delft Strategic Framework 2018-2024 CRE-04 Sustainable TU Delft Vision, Ambition and Action Plan

Appendix II

TABLE APP.II.1 Inventory of circular built environment policies

Objectives	Instruments	References
1. To reduce the intake of primary resources	1.1. Sample public and private buildings in London to estimate levels of underutilisation.	Circular Economy Route Map
	1.2. An adequate supply of aggregates to support construction in London will be achieved by encouraging reuse and recycling of C&DW, extracting land-won aggregates within London, and importing aggregates by sustainable transport modes.	The London Plan
2. To substitute unsustainably-sourced resources by sustainably produced ones.	2.1. Reduce environmental impact of aggregate sites and facilities development proposals.	The London Plan
	2.2. Identify mineral safeguarding areas to protect sand and gravel resources from exhaustion.	The London Plan
3. To develop new design and production processes to promote new ways of consumption.	3.1. Incorporate circular economy principles into public new build, refit and infrastructure.	Circular Economy Route Map
	3.2. Funding for circular built environment demonstration project.	Circular Economy Route Map
	3.3. Design guidelines to eliminate waste and for ease of building maintenance through long-life and loose fit and design for disassembly.	Design for a Circular Economy Primer
4. To reuse secondary resources (waste flows)	4.1. Research current and former mechanisms for reuse of surplus and reclaimed construction materials.	Circular Economy Route Map
	4.2. Research the implications of a reuse target for built environment projects in London.	Circular Economy Route Map
	4.3. Resource conservation, waste reduction, increased material reuse and recycling, and reduction of waste will be achieved by the Mayor, waste authorities and industry.	The London Plan
	4.4. Conserve resources, increase efficiency and source building material ethically to minimise material, energy, water and land use.	Design for a Circular Economy Primer
5. Waste reduction	5.1. Waste is sustainably managed entirely in London, waste management sites are safeguarded, treatment capacity optimised, and environmental, social, and economic benefits of waste and secondary materials are created.	The London Plan
	5.2. Manage waste sustainably and at the highest value through deconstruction, demolition and excavation operations.	Design for a Circular Economy Primer
6. Evaluation and Monitoring	6.1. Promote circular economy technologies (e.g. BIM).	Circular Economy Route Map
	6.2. Incorporate learning from ongoing projects.	Circular Economy Route Map

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TABLE APP.II.1 Inventory of circular built environment policies

Objectives	Instruments	References
7. Market development for secondary resources	7.1. Business support for built environment projects.	Circular Economy Route Map
	7.2. Investigate opportunities for an accelerator/ incubator programme.	Circular Economy Route Map
	7.3. Seek opportunities to invest in circular building opportunities.	Circular Economy Route Map
	7.4. Working group to make recommendations on developing secondary resource markets.	Circular Economy Route Map
	7.5. Innovate and pilot circular business models.	Circular Economy Route Map
	7.6. Develop a directory of circular economy products and services in London.	LWARB Business Plan
	7.7. Budget for corporate engagement in the circular economy transition.	LWARB Business Plan
8. Policy, legislation, and regulation	8.1. Incorporate circular economy principles into the London Plan and guidance documents.	Circular Economy Route Map
	8.2. Lobby for reduction of VAT for refit to be in line with zero VAT for new build.	Circular Economy Route Map
	8.3. Business Plan to set a more commercial approach to paid-for and fee services.	LWARB Business Plan
	8.4. Green infrastructure strategies should be created by Boroughs.	The London Plan
	8.5. Development Plans should use green infrastructure strategies to identify assets and opportunities to address environmental and social challenges through greening.	The London Plan
	8.6. Development Plans should assess all open space to inform policy and the creation of new areas.	The London Plan
	8.7. Boroughs should develop an Urban Greening Factor to identify the appropriate amount of greening in new developments. They should be based on GLA factors and scores.	The London Plan
	8.8. In Development Plans, boroughs should protect existing allotments and encourage space for urban agriculture.	The London Plan
	8.9. Referable applications should promote circular economy outcomes and aim to be net zero-waste in new developments. A Circular Economy Statement should be submitted.	The London Plan
	8.10. Development Plans should identify waste needs, how it will be reduced, and allocate sufficient sites for this purpose.	The London Plan
	8.11. Development proposal for material and waste management sites are encouraged.	The London Plan
	8.12. Development Plans should make provisions to maintain landbanks, ensure sufficient capacity of aggregates depots, support the production of recycled/secondary aggregates.	The London Plan

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TABLE APP.II.1 Inventory of circular built environment policies

Objectives	Instruments	References
9. Knowledge, innovation and awareness	9.1. Introduce circular economy thinking in higher education.	Circular Economy Route Map
	9.2. Conduct scoping study on the potential to implement circular economy in London.	Circular Economy Route Map
	9.3. Conduct a material resource requirements study of major infrastructure.	Circular Economy Route Map
	9.4. Work together with construction and demolition companies to identify circular economy opportunities.	Circular Economy Route Map
	9.5. Research and demonstrate circular economy opportunities in 'meanwhile' spaces in the city.	Circular Economy Route Map
	9.6. Research, innovation and demonstration of circular economy solutions.	LWARB Business Plan
	9.7. Annual Circular Economy Week event.	LWARB Business Plan
	9.8. Support SMEs wishing to transition to a circular economy through Advance London.	LWARB Business Plan
10. Ecosystem preservation and urban greening	10.1. Protection of green and open space and green features in the built environment.	The London Plan
	10.2. London's Green Belt should be protected from inappropriate development.	The London Plan
	10.3. Metropolitan Open Land has same status as Green Belt and should be extended when possible.	The London Plan
	10.4. Developments should not result in loss of protected open space.	The London Plan
	10.5. Major development proposals should contribute to the greening of London, including high-quality landscaping (including trees), green roofs, green walls, and nature-based sustainable drainage.	The London Plan
	10.6. London's urban forests and woodlands should be protected, maintained and increased.	The London Plan
11. Adaptation	11.1. Funding for behaviour change through the London Recycles programme.	LWARB Business Plan
12. Capacity building	12.1. Workshops for public and private actors to embed circular economy in refit and new build and infrastructure.	Circular Economy Route Map
	12.2. For a network of facilities and office managers to implement circular economy principles in running their buildings.	Circular Economy Route Map
	12.3. Advice and support for local authorities in delivering services.	LWARB Business Plan
	12.4. Capacity building and upskilling through the sharing on Resource London research, innovation, and demonstration outputs to public authorities.	LWARB Business Plan
	12.5. Capacity building through low cost, professional training to local authorities' employees.	LWARB Business Plan
13. Acceleration of circular economy	13.1. Research (CIRCUIT, Horizon 2020) for piloting smart, eco-friendly, regenerative, and circular practices in the built environment.	LWARB Business Plan

Appendix III

Model description

An Agent-Based Simulation (ABS) was modelled using NetLogo for the ex-ante evaluation of policy instruments for timber construction. The ABS includes the interaction of agents in the built environment (i.e. households, companies, housing associations, houses, material suppliers, demolition companies and construction companies) and the residential and commercial buildings of Amsterdam, including building-related parameters (i.e. material intensities, building distribution, floor area, recycling rates and ownership distribution). This appendix contains further information on the model's dataset, including the source of all parameters and a full description of agent interactions and assumptions in the models.

The model description was created following the Overview, Design concepts and Details (ODD) protocol for describing individual-based and agent-based models, as suggested by Grimm et al. in 2006 (figure 1). The purpose of this protocol is to establish a standardized format for describing agent-based models in detail, with the primary goal of improving reproducibility. The description is structured into seven elements and is presented visually in Figure APP.III.1.

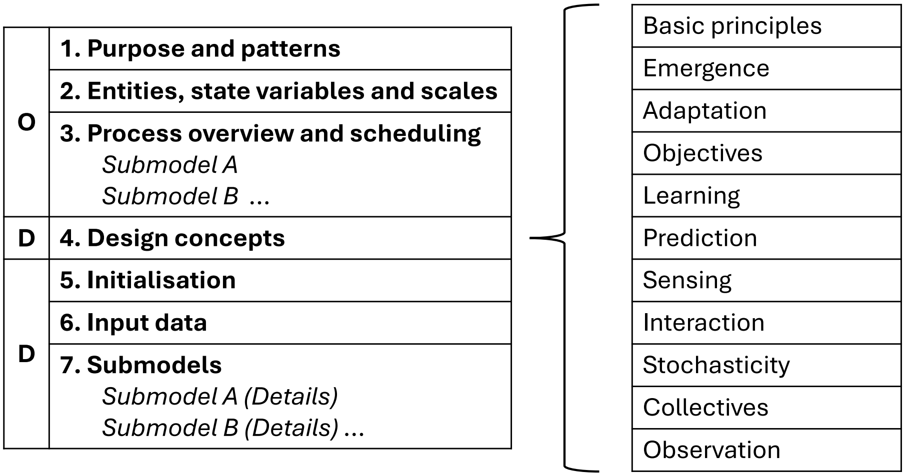

FIG. APP.III.1 Structure of model descriptions following the ODD protocol (Grimm et al., 2020)

As described in Section 6.2.2, other models have been developed for the study of complex systems in many policy areas, including the built environment (e.g. Gaudiano, 2013; Meadows et al., 1972; Portugali et al., 2012); however, these models primarily focused on different aspects of the decision-making process and not necessarily on the effect of policy instruments in relation to the making and management of the built environment (Knoeri, 2015).

Purpose

The purpose of the model is to identify possible interaction between various policy instruments that can be implemented to encourage wood-based building practices in Amsterdam. The policy instruments included in the model are: a carbon tax, a subsidy to mass timber construction, and demolition notification. The coherence analysis in Section 6.3.1 was conducted before developing the model. It revealed that economic instruments were limited, with less than a third active, forming the basis for selection criteria. Following Vedung's (1998) typology, both negative (e.g., taxes) and affirmative (e.g., subsidies) instruments were included to capture their effects. For accuracy, replicability, and simplicity, only quantifiable instruments were preselected.

Entities, state variables and scales

The model consists of the following entities: private households, companies, housing associations, and houses (residential and utility), material suppliers, demolition companies, and construction companies. The physical built environment consists of buildings (patches in the model) that are continuously manipulated through demolition and construction carried out by construction and demolition companies. Although households, companies, and housing associations play an active role in shaping the built environment and choose to change their buildings based on their preferences.

Although the model is built using data (e.g. material intensities, building distribution, floor area, recycling rates and ownership distribution) from actual buildings in the built environment of Amsterdam, the locations of the actual buildings are not taken into account. The model is not a literal spatial representation of the built environment in the city of Amsterdam. The model visualizes the different entities on a 2D grid, but their initial location on this grid has no influence on the model dynamics. Distances between buildings are also not relevant for the behaviour of the model.

The size of the 2D grid does not represent the spatial layout of the built environment. Buildings are randomly placed on the grid during the setup of the model. Consequently, the size of a cell in the grid does not correspond to the physical world's size. Apartments are not assigned to specific apartment buildings but have their own place on the grid.

The scale of the model is adjustable. This means that you can choose to model the built environment of Amsterdam on a smaller scale than in real life. This reduces computational processes but also decreases the resolution of the built environment, resulting in fewer buildings being modelled. Due to the way the model selects utility buildings, this can lead to some buildings being overrepresented in terms of their material contribution. Therefore, higher resolutions yield more accurate results.

Every house is connected to either a private owner, a company, or a housing corporation. The ownership of the buildings does not change over the duration of the simulation for the reasons that ownership mutation wouldn't be of importance when focused on aggregated behaviour. However, private owners, companies, and housing associations base their decision for a wood-based or masonry construction on different variables and therefore have different state variables.

The model consists of three housing associations, three construction companies, a demolition company, and a material supplier. It was chosen to only model one demolition company because of its limited importance in the decision for wood-based practices. Although demolition companies have the ability to decide on recycling more materials, which could be beneficial for the adoption of wood-based practices, there is no added benefit in modelling differences between demolition companies as with construction companies. The same goes for material suppliers, which, although they have some decisive freedom, are mainly passive agents.

Tables APP.III.1 to APP.III.7 list the state variables for the observer, construction company, demolition company, housing associations, material supplier, owners, and buildings. The last column mentions where the variable originates from. 'Endogenous' means that the value is determined in the model. 'Experimental' means that the value is determined by experimentation.

TABLE APP.III.1 State variables of the observer.

State variable	Description	Source
Month	The amount of ticks (months) since the start of the simulation.	Endogenous
Buildings_constructed	The amount of buildings constructed over the course of the simulation.	Endogenous
Buildings_demolished	The amount of buildings demolished over the course of the simulation.	Endogenous
Masonry_based_buildings	The amount of buildings primarily constructed of masonry-based materials.	Endogenous
Wood_based_buildings	The amount of buildings primarily constructed of wood-based material.	Endogenous
[material]_landfilled	The quantity of material landfilled over the course of the simulation.	Endogenous
[material_requested	The quantity of material requested over the course of the simulation.	Endogenous
Primary_[material]	The quantity of material sourced from a primary source over the course of the simulation.	Endogenous
[material]_demolished	The quantity of material demolished over the course of the simulation.	Endogenous

TABLE APP.III.2 State variables of the architecture and construction company.

State variable	Description	Source
Project_capacity	The construction capacity in m^2.	Experimental
Specialisation	The specialization in wood-based or masonry practices.	Endogenous
Projects	The projects currently under construction by the construction company.	Endogenous

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TABLE APP.III.3 State variables of the demolition company.

State variable	Description	Source
Project	The projects currently being demolished by the demolition company.	Endogenous

TABLE APP.III.4 State variables of the housing associations.

State variable	Description	Source
Assets	The buildings that belong to the housing associations.	Endogenous
Material_preference	The preference for either wood or masonry-based buildings.	Experimental

TABLE APP.III.5 State variables of the material supplier.

State variable	Description	Source
Stock_steel	The amount of steel stock in kg.	Endogenous
Stock_wood	The amount of wood stock in kg.	Endogenous
Stock_concrete	The amount of concrete stock in kg.	Endogenous

TABLE APP.III.6 State variables of the private, company and other owners.

State variable	Description	Source
Assets	The buildings that belong to each of owners	Endogenous
Material_preference	The preference for either wood or masonry-based buildings.	

TABLE APP.III.7 State variables of the buildings.

State variable	Description	Source
Status	The current status of the building.	Endogenous
Time_empty	The time the plot has been empty. When there was no building constructed on the plot.	Endogenous
Building_type	The type of building; apartment, single family, row, office and shop.	Endogenous
Buildings_contruction_year	The year in which the building is constructed.	
Building_floor_surface	The floor surface of the building when constructed in m^2.	
Remaining_lifespan	The remaining lifespan of the building when constructed in months.	
Owner	The owner of the building, either private, company or housing association.	
Kg_concrete	The amount of concrete in the building when constructed in kg.	
Kg_wood	The amount of wood in the building when constructed in kg.	
Kg_steel	The amount of steel in the building when constructed in kg.	
Material_type	The material type of the building either wood-based or masonry.	Endogenous

Process overview and scheduling

The simulation follows a 12-step schedule. During a single iteration of the model, firstly, building owners evaluate their stock and submit demolition and cost requests. This is followed by construction companies and material suppliers handling project estimates, material costs, and commissions. (Project details, construction timelines, and building parameters are updated as projects progress). Demolition companies then manage material stock and timelines, sending secondary materials to suppliers. Throughout, messages are exchanged between parties via inboxes and outboxes. The process repeats until all messages are resolved, followed by updating building lifespans and the simulation runtime counter monthly. A new iteration of the model is then started. The following schedule is repeated with every model step. The general flowchart is displayed in Figure APP.III.2.

1. All owners (private_owners, company_owners, and housing associations) are asked to evaluate their building stock.
   a. Demolition requests are placed in the outbox.
   b. Construction cost requests are placed in the outbox.

2. All owners (private_owners, company_owners, and housing associations) are asked to check their inbox.
   a. Construction project estimates are evaluated based on a set of criteria.
   b. Construction commissions are placed in the outbox for the construction companies.

3. All construction companies are asked to check their inboxes.
   a. Material cost requests are placed in the outbox for the material supplier.
   b. Projects are added to the project list.
   c. Construction cost estimates are placed in the outbox for the owners.

4. All construction companies are asked to check their projects.
   a. Construction time is updated for every construction project.
   b. Building parameters are updated.
   c. The project is removed from the project list.
   d. The construction counter is updated.
   e. Specialization parameter is adapted

5. The demolition company is asked to check its inbox.
   a. Projects are added to the project list.
   b. Secondary material is sent to the material supplier.

6 The demolition company is asked to check its projects.
   a The demolition time is updated for every demolition project.
   b The plot parameters are updated.
   c The projects are removed from the project list.
   d The demolition counter is updated.

7 The demolition company is asked to clear its material stock.
   a Secondary material request is sent to the material supplier.

8 The material supplier is asked to check its inbox.
   a The material costs are calculated for buildings.
   b Primary material response messages are placed in the outbox for the respective construction companies.
   c Secondary material response messages are placed in the outbox for the demolition company.
   d The material stock is updated.

9 The model checks if there are any messages in any of the outboxes.
10 All messages are sent out from the respective outbox of the sender to the respective inbox of the receiver.

The steps above are repeated until no messages are send anymore, resulting in that there are no messages in any of the outboxes. When this is the case, the following steps are executed:

11 The remaining lifespan is reduced by one month for every building.
12 One month is added to the simulation runtime counter.

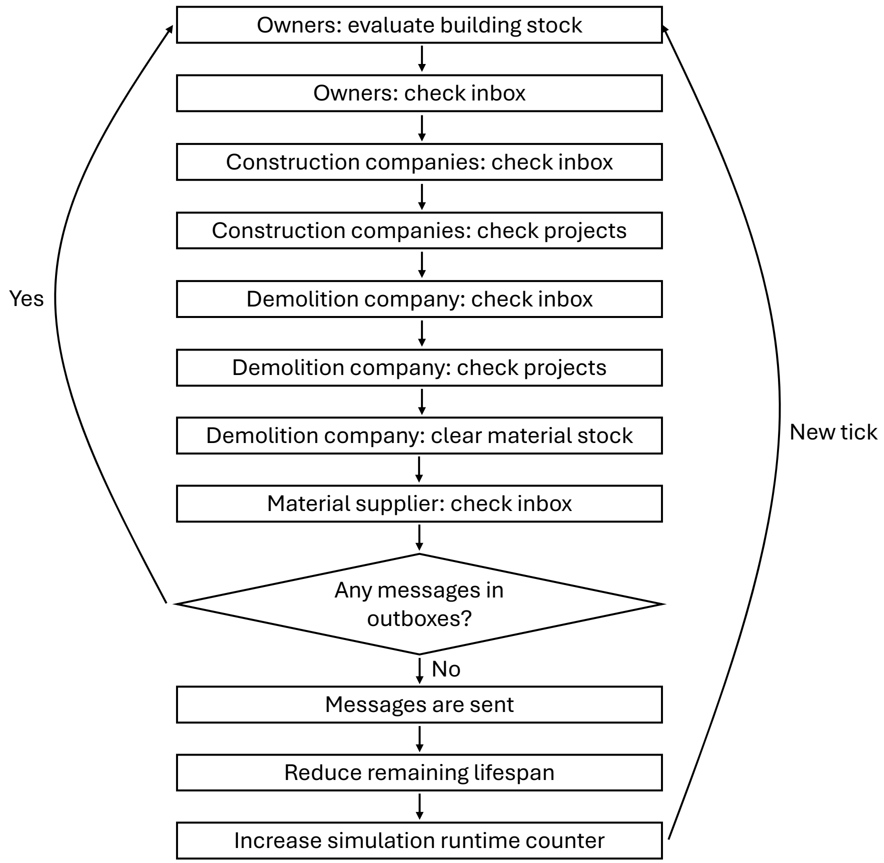

FIG. APP.III.2 Figure 2. Flowchart of the model schedule. Source: the authors.

The model operates through a messaging system. Each actor has both an inbox and an outbox used for receiving and sending messages. Based on its state, the state of its assets, or an incoming message, the actors initiate actions or send out messages. After initialization, all buildings are placed in the environment and allocated to owners.

The first model step starts with asking all owners, whether they are private owners, company owners, or housing associations, to evaluate their assets. Assets can encompass buildings and plots, and ownership remains unchanged over the course of the model runtime. Whenever a building has reached the end of its operational life, registered by the model as a remaining lifetime of zero months, the owner sends out a request message to the demolition company for demolishing the asset. The demolition request is then added to the outbox of the owner.

Whenever a plot is vacant, the owner takes action to construct a building. At first, a building type is determined by the owner. This is done based on a distribution of building types in the city of Amsterdam and can differ from what was historically present on the vacant plot. Determining the properties of a new building is a stochastic action. Subsequently, depending on the building type, a floor surface is selected. The owner verifies if there is sufficient project capacity among the construction companies to fulfill the construction order, and if this is the case, a request is generated and placed in the owner's outbox. Whenever the project capacity is not sufficient for constructing the building, no request is sent. After a request is sent, the status of the building (patch) is changed. After a construction cost request, the status is changed to waiting_for_construction_cost_estimate. After a demolition request, the status is changed to waiting_for_demolition_company. The patch color is altered based on the status of the building.

The second model step is to ask all owners to review their inboxes. When an owner receives a construction cost estimate from a construction agent, the construction project is added to an evaluation list. All construction cost estimates are grouped per building patch, and for every patch, the lowest cost option for wood-type buildings and the lowest cost option for masonry-type buildings is calculated. An owner prefers a wood-based or masonry-based building based on the price in the construction cost estimate, but also on other characteristics. Housing associations take into consideration their familiarity with both material types. The more familiar they are with wood-based buildings, the more likely they are to choose to construct their new building with wood as a basis. Familiarity is modeled by evaluating their current assets and checking how many buildings are constructed with mass timber as a basis, and how many buildings are constructed with masonry materials. Private and company owners are influenced by their surroundings. Whenever the building patch is surrounded by masonry buildings, the owner is more likely to choose a masonry-based building, and vice versa. The personal preference is expressed as a perceived extra cost and added to the construction price. The lowest perceived construction cost estimate is then placed in the outbox as a construction_commission_request for the respective construction company agent.

The third model step is to ask all construction companies to review their inboxes. When a construction company receives a construction cost request, the material quantities for wood, steel, and concrete are calculated for both a wood-based building and a masonry-based building. In order to get an estimation for the total materials cost, a material cost request is generated and put in the outbox to be sent to the material supplier.

Whenever a construction commission is received, first, the remaining project capacity is updated. The construction company verifies if it has enough capacity to construct the building. If the construction company lacks the required project capacity, the project is canceled, and the status of the patch is set to 'empty' again. Whenever the project capacity is sufficient, the project is added to the project list together with a project duration. Masonry buildings have a different construction time relative to wood-based structures. The status of the patch is then changed to 'under_construction.'

When a construction company receives a 'primary_material_response' from the material supplier, this indicates that the material supplier has calculated the material cost for a building project. The construction company then calculates the cost for both a masonry-based building and a wood-based building depending on the material cost, building type, specialization component, and the material type. The construction cost estimates are put back in the outbox in the form of a message to be sent back to the owner.

The fourth model step is to ask the construction companies to review their construction projects. The construction time depends on the material type and the building floor surface area. With each step, the remaining construction time is reduced by a month. Whenever the remaining construction time is zero, the construction project is completed. The parameters of the building are assigned to the corresponding patch, and the project is removed from the project list. The construction company adjusts its specialization component based on the building's material type. Finally, the building construction counter is updated.

The fifth step of the model is to ask the demolition company to review its inbox. When the demolition company receives a demolition request from an owner, the demolition project is added to the project list. The demolition company has no capacity constraints and therefore accepts all demolition projects. The demolition project is added to the demolition projects list together with a demolition time component.

Whenever the demolition company receives a secondary_material_response from the material sup- plier, it will reduce its material stock by the amount of concrete, steel, or wood as indicated by the material supplier. Material that cannot be recycled due to capacity limitations on the side of the material supplier is then landfilled.

In the sixth step, the demolition company is asked to review its projects. Every month, the remaining demolition time of each project is reduced by one. When the remaining demolition time is zero, the building is completely demolished. The extracted building material, including wood, concrete, and steel, is added to the material stockpile of the demolition company. The parameters of the building patch are then set, and the demolition counter is updated.

In the seventh step, the demolition company is asked to clear its material stock. Every month, the demolition company gathers all the material from all demolition activities in its stock. This material can either be landfilled or recycled. The demolition company will try to recycle as much of the material stock as possible. Therefore, the demolition company puts a message in its outbox to the material supplier, with the amount of material currently in stock. The material that can be recycled will go to the material supplier; the other material is landfilled.

In the eighth step, the material supplier is asked to review its inbox. When the material supplier receives a material request, it calculates the material cost for the construction project. The material cost is based on the quantity of concrete, wood, and steel. The material_cost_response is put in the outbox to be sent to the construction company.

When the material supplier receives a secondary_material_request, the amount of secondary material that can be handled by the material supplier is reviewed, and a message with this quantity is sent back to the demolition company.

The next step is to check if there are any messages in one or multiple agents' outboxes. If there are messages present, the messages are sent from the respective outbox of the sender to the respective inbox of the receiver. The model then starts again at the first step and iterates until no messages are being sent anymore, and all outboxes are empty. Once this condition is met, the remaining lifespan of the buildings is reduced by one month, and a month is added to the simulation runtime counter.

Appendix IV

Operationalising the Circular city policy coherence framework

The purpose of this appendix is to provide a deeper insight into the operationalisation of the circular city policy coherence framework for the TU Delft and Greater London cases in chapters 4 and 5 respectively. In particular, this appendix provides information on how the coding and qualitative data were used for the policy coherence analysis, an explanation of the interview samples in relation to the research design, the results of the interviews and further evidence from the data to support the findings. Note that most of this information was included in the datasets for each case and uploaded to the 4TU.ResearchData Repository for examination. A link to each dataset is provided in chapters 3, 4, 5 and 6.

Chapter 4 – Circular city policy coherence in campus development at Delft University of Technology

Qualitative data and coding

Three rounds of coding were carried out for the analysis of the 14 policy documents included in Chapter 4. The first round of coding was open coding, aimed at identifying references to policy objectives and instruments in general (e.g. regulatory, economic and information instruments - or sticks, carrots and sermons, following the work of Vedung 1998). This was followed by two rounds of theoretical coding, the first aimed at identifying implicit and explicit references to the analytical units contained in Williams' (2019) circular city development framework, Nilsson et al.'s (2014) policy coherence analysis framework, and Ranabhat et al.'s (2018) factors for policy coherence (Table APP.IV.1). The final round of coding was carried out to ensure a thorough review and to avoid missing implicit and explicit references.

TABLE APP.IV.1 Theoretical coding

Framework	Aspect	Code
Circular city development	Looping	CA01
	Ecologically regenerative	CA02
	Adaptation	CA03
Policy coherence analysis	Goals	PL01
	Instruments	PL02
	Implementation	PL03
Factors for policy coherence	Motivation	PF01
	Measures	PF02
	Implementation plan	PF03
	Resources	PF04
	Monitoring and evaluation	PF05

Evidence underpinning findings

A code co-occurrence diagram of the relationship between circular actions and levels of policy analysis provides further evidence of their relationship. A Sankey diagram is presented as to portrait the relationship between the coding for circular actions (i.e. CA01, CA02, CA03) and for levels of policy analysis (PL01, Pl02, PL03) in Figure APP.IV.1. In addition, all data and evidence supporting the findings of this chapter can be found via the link to the 4TU.Research repository provided in Chapter 4.

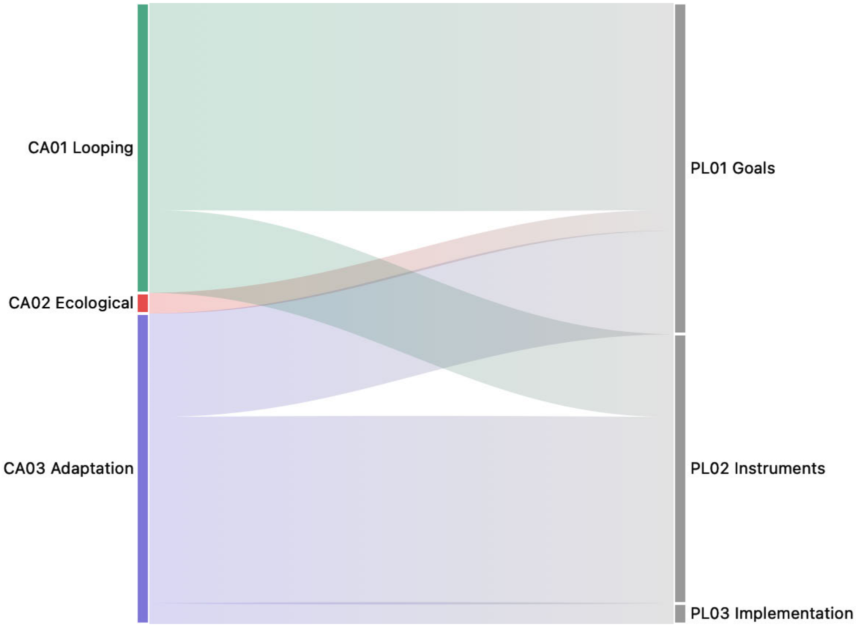

FIG. APP.IV.1 Code co-occurrence diagram for the relation between circular actions and levels of policy analysis in selected policy documents.

Interviews design and sampling

Semi-structured interviews were used for this project. Semi-structured interviews offer the opportunity to improve the replicability of questions, making the data more reliable as the same questions to different actors improve the consistency of the data collection process and allow generalisation of findings (Sarantakos, 2013). As structured interviews tend to be insensitive to participants' needs, produce restrictive responses and are therefore not suitable for exploring complex issues and opinions, moving slightly towards a more unstructured setting (or semi-structured) may allow unexpected findings to emerge by allowing participants to be more flexible and responsive (Knight and Ruddock, 2008).

Interview sampling considered experts in the field of campus sustainability, considering areas such as health and wellbeing, energy, building and renovation, and ecology. The size of the sample was determined following Gubrium et al. (2012) suggestions on 6-12 participants provided there is thematic redundancy and saturation after interviewing at least 6 participants. As the research looks into policy objectives and goals, thematic saturation was considered reached once no new instruments were identified through the interviews.

The interview process began by contacting potential interviewees by email and asking about their willingness and availability to participate in the research project. Once the interviewer and interviewee agreed on a date and time, they were given a consent form and a brief introduction to the project. At the time of the interview, the procedure was as follows. Firstly, a brief introduction to the relevance of the study and the use of data from the interviews was provided, and verbal consent to record the session was obtained. Secondly, the interviews were structured around 6 questions to 1) contextualise the role of the sustainability expert in campus development at TU Delft, 2) their awareness of the university's goals, 3) the tools they use in their work in relation to making the campus more sustainable, 4) how the sustainability goals have affected their role in the organisation, and 5) what other tools they think could improve the effectiveness of circularity in campus development. The questionnaire included the following:

1 Are you aware of the CRE policy goals on circularity, carbon neutrality and better health & wellbeing in campus development by 2030?
1 How does your job and role at the TUD link to these CRE goals?
2 What instruments or tools (are there or) do you use to work on the goals? What (other) instruments do you think are needed?
3 What implementation measures have been taken or proposed to achieve the CRE goals to date? What (other) measures do you think are needed?
4 Overall, have these policy goals had any influence in your work decisions? Have they had any effect on your work and/or your role at TUD?
5 What other goals, instruments and/or implementation measures would you suggest for achieving the CRE goals on circularity, carbon neutrality and better health & wellbeing in campus development?

The treatment and analysis of data was conducted as mentioned in section 4.4.

Qualitative data and coding

Three rounds of coding were carried out for the analysis of the 6 policy documents included in Chapter 5. The first round of coding was open coding, aimed at identifying references to policy objectives and instruments in general (again, regulatory, economic and information instruments - or sticks, carrots and sermons, following the work of Vedung 1998). The two subsequent rounds of coding were theoretical, the first aimed at identifying implicit and explicit references to the analytical units contained in Williams' (2019) circular city development framework, Nilsson et al.'s (2014) policy coherence analysis framework, and Ranabhat et al.'s (2018) factors for policy coherence (Table APP.IV.2). The final round of coding was carried out to ensure a thorough review and to avoid missing implicit and explicit references.

TABLE APP.IV.2 Theoretical coding

Framework	Aspect	Code
Circular city development	Looping	CA01
	Ecologically regenerative	CA02
	Adaptation	CA03
Policy coherence analysis	Goals	PL01
	Instruments	PL02
	Implementation	PL03
Factors for policy coherence	Motivation	PF01
	Measures	PF02
	Implementation plan	PF03
	Resources	PF04
	Monitoring and evaluation	PF05

Interviews design and sampling

Semi-structured interviews were used for this project. Semi-structured interviews offer the opportunity to improve the replicability of questions, making the data more reliable as the same questions to different actors improve the consistency of the data collection process and allow generalisation of findings (Sarantakos, 2013). As structured interviews tend to be insensitive to participants' needs, produce restrictive responses and are therefore not suitable for exploring complex issues and opinions, moving slightly towards a more unstructured setting (or semi-structured) may allow unexpected findings to emerge by allowing participants to be more flexible and responsive (Knight and Ruddock, 2008).

The interview sample considered experts in the field of sustainable construction, considering areas such as building research, mass timber and modular construction, local sustainable construction organisations, the Mayor of London's Advisory Design Group and a sectoral sustainable construction organisation. The size of the sample was determined by following Gubrium et al. (2012) suggestions of 6-12 participants, provided there was thematic redundancy and saturation after interviewing at least 6 participants. Out of 20 possible interviewees contacted, only 6 responded positively and participated in the project. As the research is concerned with policy objectives and goals, thematic saturation was considered to have been reached when no new instruments were identified through the interviews. Having an interviewee from ReLondon with responsibility for circular built environment policies was key to ensuring that all policy objectives and instruments were identified.

The interview process began by contacting potential interviewees by email and asking about their willingness and availability to participate in the research project. Once the interviewer and interviewee agreed on a date and time, they were given a consent form and a brief introduction to the project. At the time of the interview, the procedure was as follows. Firstly, a brief introduction to the relevance of the study and the use of data from the interviews was provided, and verbal consent to record the session was obtained. Secondly, the interviews were structured around 6 questions to 1) contextualise the role of the sustainability expert in campus development at TU Delft, 2) their awareness of the university's goals, 3) the tools they use in their work in relation to making the campus more sustainable, 4) how the sustainability goals have affected their role in the organisation, and 5) what other tools they think could improve the effectiveness of circularity in campus development. The questionnaire included the following:

Operationalisation of the framework and further evidence of synergies and conflicts

The Circular city policy coherence framework was used for the analysis of circular city development in Greater London. It resorted to two policy domains, namely, circular economy and planning. Six policy documents were included in this research project, which were identified through desk research and 6 semi-structured interviews. Twelve overarching policy objectives were proposed to cluster 55 instruments identified in these policies (Appendix II includes the list of objectives and instruments). After the clustering of objectives and instruments, three rounds of analysis followed. The first round identified explicit and implicit references to circular actions (i.e. looping, ecological regeneration, and adaptation). The second round looked into the possible synergies and conflicts among instruments linked to a single objective. Note that not all overarching objectives included instruments from both circular economy and planning domains. The second round looked into the possible synergies and conflicts in the interaction of all goals and instruments. All possible synergies and conflict were consolidated in an MS Excel file for data extraction.

Seventeen possible synergies and 1 conflict were identified in relation to a single objective and the two policy domains. For instance: Synergies:

Objective 1. To reduce the intake of primary resources. Within this objective, instrument 1.1 on the estimation of asset underutilisation in public and private buildings is part of the Circular Economy Route Map. A possible synergy between circular economy and planning as domains is here identified as instrument 8.9, on the promotion of circular economy outcomes and net-zero waste in new development. This synergy may lead to a small reduction in new build.

Objective 3. To develop new design and production processes to promote new was of consumption. Instrument 3.2 provides funding for circular economy environment demonstration projects, which may lead to synergies with the implementation of the Circular Economy Statement (instrument 8.9), mandatory to all major developments in Greater London.

Objective 3. To develop new design and production processes to promote new was of consumption. Instrument 3.3 proposes design guidelines to eliminate waste and for ease of building maintenance through long-life and loose fit and design for disassembly. In this case an instrument from the circular economy domain ended up being an instrument in the planning domain through its inclusion in the London Plan (i.e. Circular Economy Statement).

Objective 4. To reuse secondary resources (waste flows). Instrument 4.4. from the Design for A circular Economy Primer, on the conservation of resources, increased efficiency and the ethical sourcing of building materials to minimise materials, energy water and land use, ended up being included as instrument in the planning domain through its inclusion in the London Plan (i.e. Circular Economy Statement). Conflicts:

Objective 8. Policy, legislation, and regulation. Instrument 8.2, on facilitating lobby for the reduction of Value Added Tax (VAT) for refit to be in line with zero VAT for new build, shows a possible conflict that could diminish the support of circular built environment interventions and development in Greater London. Because, despite current economic instruments such as instrument 3.2, building new developments keep on being cheaper than refitting the current building stock.

Curriculum vitae

Felipe Bucci Ancapi is policy researcher and analyst with a decade of experience in areas of urban governance, disaster risk management, environmental management, and circular economy. He holds a BA in Political Science and Public Administration by University of Concepcion, Chile, and a MSc in Urban Environmental Management by Wageningen University and Research, the Netherlands.

Between 2014 and 2015, Felipe worked as project manager at the Department for Integrated Disaster Risk Management at the Municipality of Talcahuano, Chile. There he acquire knowledge and know-how in relation to collective mapping of territorial hazards, earthquake and tsunami early-response and drilling, and applied public administration.

Between 2015 and 2017, Felipe enrolled in the MSc in Urban Environmental Management and moved to Wageningen. Throughout the masters, Felipe developed skills in relation to environmental systems analysis (his major) and environmental philosophy (his minor) and applied them in a thesis that sought to critique the value of nature in the context of ecosystem services-based nature conservation. In 2016, together with other students from Wageningen University and Research, Felipe became a founding member of the Circular Economy Student Hub, organisation that hosted the 2017 Circular Economy Fashion Week and the 2016 International BioBased Economy Student SymbioSUM (IBBESS).

Between 2017 and 2019, Felipe worked as researcher in the Department of Architecture, University of Concepcion, Chile, as well as Manager of the Recycling Plan of University of Concepcion and Manager of circular economy projects at the Centre for Bioeconomy of the same university. Additionally, Felipe work as lecturer of Environmental Management and Urban Metabolism at University of Concepcion and of Political Economy and Theory of Public Administration at the Catholic University of Temuco, Chile.

Between 2020 and 2024, Felipe pursued his PhD at Delft University of Technology, where he joined the Circular Built Environment Hub (CBE Hub) at the Faculty of Architecture and the Built Environment. Through the CBE Hub, Felipe got a temporary position as researcher of policy coherence at the Campus Real Estate & Facility Management (CREFM) Department of TU Delft. In 2021, Felipe joined the CircuLaw project at the City of Amsterdam as research partner on behalf of TU Delft, position that Felipe held till 2024. In 2023, Felipe spent 2 months as visiting researcher at the Bartlett School of Planning, University College London (UCL), UK, under the supervision of Prof.dr. Jo Williams. Felipe also fulfilled lecturing responsibilities during his PhD. In total, Felipe supervised 3 master's theses in the field of circular economy policy in relation to taxation, stakeholder perceptions, policy instruments and computational modelling. Additionally, Felipe supervised 2 group projects from the master programme Industrial Ecology between Leiden University and TU Delft in the field of circular economy, more specifically on data management for circular economy accounting and circular resource management in Scheveningen, the Netherlands. At the Advanced Metropolitan Solutions (AMS) Institute in Amsterdam, Felipe co-lectured in the course Metropolitan Solutions and supervised a group project as part of the Living Lab course. Between 2021 and 2022, Felipe participated online as lecturer of urban sustainability in the Master's Degree in Resilient Management and Architecture for Disaster Risk Management of the Faculty of Architecture, Urbanism and Geography at University of Concepcion, Chile.

Additionally to his academic duties, Felipe freelanced as an external consultant to the Organisation for Economic Cooperation and Development (OECD) between 2023 and 2024. Felipe participated in the project 'Enabling the governance of the circular economy in cities and regions' in support of the Circular Cities and Regions Initiative (CCRI) of the European Union. Felipe served as an expert for 5 case studies, namely, Province of Zuid-Holland (Netherlands), Eurométropole of Strasbourg (France), Møre and Romsdal Region (Norway), Berlin (Germany), and Region of Central Macedonia (Greece).

List of publications

Peer-reviewed journal papers

2024 **Bucci Ancapi, F.**, Kleijweg, M., Yorke-Smith, N., Van den Berghe, K., van Bueren, E.. How ex ante evaluation supports circular city development: Amsterdam's mass timber construction policy. *Environmental Management.* (under revision).

2024 **Bucci Ancapi, F.,** Van den Berghe, K. B. J., & van Bueren. Circular city policy coherence in Greater London. *Cities.* https://doi.org/10.1016/j.cities.2024.105423.

2023 **Bucci Ancapi, F.** Ex ante analysis of circular built environment policy coherence. *Buildings & Cities.* https://doi.org/10.5334/bc.337

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2023 **Bucci Ancapi, F.**, Van den Berghe, K. B. J., & van Bueren, E. (2022). A Policy Coherence Framework for Circular Built Environment Implementation: the Case of a Campus Development. In S. Shahnoori, & M. Mohammadi (Eds.), The state of circularity: The content of "the 2nd International Conference on Circular Systems for the Built Environment" (pp. 120-136). Technische Universiteit Eindhoven. https://research.tue.nl/en/publications/the-state-of-circularity-the-content-of-the-2nd-international-con/projects/

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2022 **Bucci Ancapi, F.**; van Bueren, E.; Van den Berghe, K. *Circular Cities*. In The Palgrave Encyclopaedia of Urban and Regional Futures (pp. 1-12). Palgrave McMillan. https://doi.org/10.1007/978-3-030-51812-7_125-1

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2024 *The Circular Economy in Central Macedonia, Greece,* OECD Urban Studies, OECD Publishing, Paris. (Forthcoming)

2024 OECD. *The Circular Economy in Berlin, Germany,* OECD Urban Studies, OECD Publishing, Paris. https://doi.org/10.1787/459defe7-en

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2024 OECD. *The Circular Economy in Zuid-Holland, the Netherlands,* OECD Urban Studies, OECD Publishing, Paris. https://doi.org/10.1787/d568d66e-en

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Improving policy coherence for circular cities

Evaluating circular built environment policies of London and Amsterdam

Felipe Bucci Ancapi

This dissertation develops an understanding of circular built environment policies. It draws of Jo Williams' Circular City Development and Måns Nilsson et al. Policy Coherence analysis Framework to propose a framework for ex ante circular city policy coherence analysis, which is developed and tested through three case studies: campus development at TU Delft (Netherlands), circular built environment policy in Greater London (UK), and mass timber construction policy in Amsterdam (Netherlands). The dissertation uncovers policy formulation by means of circular economy policy objectives, instruments and implementation practices. It shows that in the selected case studies, circular economy policies are increasing their coherence by means of supply chain and business driven circular economy frameworks, but less so in developing circular urban systems. Currently, the circular built environment policies analysed throughout this dissertation are based on looping actions (e.g., recovery, recycling, reusing) and tend to overlook ecological regeneration actions (e.g. blue and green infrastructure and urban ecosystem services provision) and adaptation actions (e.g. community-led co-creation and capacity building). Ultimately, this dissertation argues that current circular built environment policies 'cannot see the city for the buildings' and that ex ante evaluation of circular city policies can contribute to improve the alignment and synergies between policy objectives, instruments and implementation practices towards circular city development.

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