Neighbourhoods of the Circular City – How circular city strategies are implemented at the neighbourhood level

A qualitative analysis of circular city strategy implementation at the scale of housing and the neighbourhood

Master's Thesis for MSc Spatial Planning – European Spatial & Environmental Planning (ESEP) Specialisation

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Colophon

Abstract: The circular city is the latest step in the progression of cities towards creating more sustainable systems. Cities across Europe have prepared circular economy strategies that will shape how their cities develop in the future, in response to environmental challenges in a rapidly urbanising world. These circular economy strategies result in the movement of urban spaces towards the 'circular city'. The implementation of the circular city vision will translate to the level of spatial planning, housing and the neighbourhood, and affect how we live within the city. Whilst both 'top-down' and 'bottom-up' interventions have begun being implemented for a transition to the circular city, it is important to identify how this circular transition affects housing, neighbourhood development, and the day-to-day life of people within our cities.

Keywords: Circular Economy, Cities, Housing

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Preface

This thesis has been carried out as part of the completion of my MSc Spatial Planning – ESEP Specialisation at Radboud University Nijmegen. The topic of this thesis is the implementation of Circular City strategies at the level of the neighbourhood within cities. The research was carried out in Nijmegen and Weesp, The Netherlands.

I would like to thank my Thesis Supervisor Dr Peter Ache, for providing guidance and feedback during my research. I am also grateful to have carried out an Internship with a Circular Consultancy – Metabolic in Amsterdam which inspired my interest in the field of spatial planning for circular cities. Finally, I would like to thank the participants of my expert interviews who provided invaluable input for my research and additional feedback on my results.

Summary

The Circular City is a recent concept that is defined by the application of principles of the Circular Economy across the physical elements of the city and its broad functions. A response to the growing resource consumption and waste production problems which face the world's cities, the Circular City aims to reduce the waste that is produced by our cities, through extracting as much value as possible from existing materials and resources (including waste) as well as reducing or completely avoiding the use of newly extracted resources from the Earth.

Circular City strategies have begun being implemented by cities to transform current economic activities within urban environments, but also to shape a sustainable built environment, and change the behaviour of business and residents within cities. The concept requires the closing of material loops amongst the functions of the city, including in building and construction, energy production, and waste processing. Spatial planning is a key element of the circular transition in urban regions, towards a circular city and involves the transformation of economies, the built environment, and the natural environment within out cities. This thesis focuses on the implementation of Circular City strategies and their impact upon the neighbourhood as a unit of the city. It looks to examine how these strategies will eventually shape *how* people live in the circular city with a focus on neighbourhood development, spatial planning for circularity, and the future interactions and functions of neighbourhoods within the city.

The study is carried out using qualitative methods consisting of desk research, document analysis, and Delphi method – expert interviews. The research identifies current theoretical and conceptual perspectives on the topic of the Circular City, which allowed for the adaptation of an existing research framework to be applied to a document analysis of seven Circular City strategy documents. The document analysis was carried out using a hybrid deductive-inductive approach, first by 'questioning' each strategy against the adapted framework to identify relevant data extracts, and then by coding and analysing the documents for a deeper level of interpretation. Finally, interviews were carried out as a form of triangulation which supplemented the document analysis and provided a perspective from two experts on the topic of research. A second round of expert feedback was obtained from one expert who provided additional reflection upon the results of the research and answers to research questions.

The results of this thesis examines the dominant themes of Circular City strategies, as well as unexpected outliers and concepts raised within expert interviews. It identifies the potential opportunities as well as limitations of circularity when applied to the neighbourhood and characterises the role of spatial planning for neighbourhoods in the CC, its interconnected elements including societal collaboration and innovative use of data and novel technologies, and its anticipated impacts upon residents within our neighbourhoods. The final adapted research framework provides a concise summary of the research findings and provides a starting point for future considerations in spatial planning for circular neighbourhoods.

List of Acronyms

CE – Circular Economy

CC – Circular City

EU – European Union

EC – European Commission

EMF – Ellen Macarthur Foundation

GHG – Greenhouse Gas Emissions

IRP – International Resource Panel

MFA – Material Flow Analysis

UN – United Nations

WEF – World Economic Forum

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1. Introduction

1.1 Background

The transition to a circular economy (CE) is a recent target of a number of local and national governments, businesses and international bodies across Europe. Planning for the future of their urban and economic development, the goal of this transition is to orientate their economic activities towards a more sustainable state. The United Nations New Urban Agenda provides a guide for the planning of cities to promote more sustainable and inclusive urban economies, and for cities themselves to manage their resources more sustainably and mitigate their impacts upon the natural environment (UN Habitat 2017). The European Commission has recently established a new growth strategy for the European Union – The European Green Deal. In combination with its action plan, the Green Deal introduces a focus on the transition to a circular economy through sustainable and resource-efficient growth for a competitive economy, coupled with the restoration of biodiversity, and reduction in pollution (European Commission 2019). Further, The Netherlands amongst other countries across the world has realised an ambition to transition to a fully circular economy by 2050 (Government of the Netherlands 2016).

The concept has developed in response to the challenge of resource scarcity in the face of environmental challenges on a rapidly urbanising planet. Trends indicate that the majority of the world's population will live in urban areas in the future – the United Nations World Urbanization Prospects Report 2018 projects approximately 70% - 6.7 billion people of the world to be living in urban areas by 2050 (UN, 2018). Further, material consumption in cities is predicted to reach 90 billion tonnes by the same year, being an increase of 50 billion tonnes from 2010 (IRP 2018).

Circular economy strategies emerging at the international level focus largely on reduction of material consumption through sustainable product design and production processes, reducing and preventing waste production, innovation in circular businesses, and creating resource efficient environments (European Commission 2015, World Economic Forum 2018, IRP 2018). The transition to a CE involves the transformation of current economic and industrial systems into low-emission and regenerative models that replace the end-of-life of a product with reuse, recycling or recovery of materials (Kirchherr, Reike and Hekkert 2017). In the EU, the number of jobs linked to the CE – being jobs related to repair and maintenance, and waste and recycling industries have increased from 2012 to 2018 to around 4 million (European Commission 2015). The European Green Deal identifies the opportunity for this employment potential to continue to grow, with the CE transition further offering new economic sectors and the expansion of sustainable and job-intensive economic activity, for example in building renovation for energy and resource efficiency or in innovative sustainable technologies (European Commission 2019).

Cities are identified as being in a unique position to act as catalysts for the transition to a CE, as they are made up of complex systems that involve the intersection of people, business, government, housing, transportation, diverse land uses, and infrastructure. As such, cities have been identified as key drivers in the transition to a CE, given their growing nature and role in contributing to global problems of resource scarcity and climate change (European Commission 2019, World Economic Forum 2018, IRP 2018). In Europe, the opportunity for cities to serve as 'Living Labs' is an example of the practical support for the transition to a CE. Living Labs and

other circular city funding initiatives involve encouraging investment in the circular economy through EU project funding and support of innovative sustainability solutions in the city by citizens, municipalities, researchers and businesses in coordination with one another (Santonen et al. 2017, Circular City Funding Guide 2020). Further EU funded projects such as the 'Horizon 2020/Bio-based Industries Joint Undertaking' involve the support of specific projects related to the CE or circular bio-based economy across target sectors of buildings, plastics, waste, water, and urban planning and cultural heritage (European Commission 2020). Beyond this materials-focused circular project support, city governments themselves have begun to introduce strategic plans that guide their approach to becoming a circular city.

The concept of the CE has been adopted as a tool by cities to form their transition to becoming a circular city (CC). Cities are in a prime position to engage in urban sustainability transitions due to their impacts as resource consumers but also their ability to engage various actors across multiple dynamics and scales to experiment with sustainability solutions (Loorbach et al 2016). While the definition of a circular city is still being contributed to and built upon (Prendeville et al. 2017), the concept has been broadly identified as the incorporation of the principles of a CE across all the 'functions of the city' (Ellen MacArthur Foundation, 2017). It aims to create "prosperity and economic resilience for itself and its citizens while decoupling value creation from the consumption of finite resources" (World Economic Fund 2018, pp.10). Cities throughout Europe have adopted CC strategies in recent years, including Amsterdam (Circle Economy et al. 2016) and Rotterdam (Rotterdam Circulaire 2019) in the Netherlands, London (LWARB 2017) in the United Kingdom, Paris (Mairie de Paris 2017), and Bern (Circle Economy 2019). Global cities such as New York, in the US (New York Circular City Initiative 2019) and Toronto, Canada (Ellen Macarthur Foundation 2019) have also been identified in vision documents for their transition to a CC.

The implementation of these strategies across cities seek to have transformative and meaningful impacts upon citizens, businesses, government, mobility, and both the built and natural environment in the city. Transitions to a circular economy do not only involve a reorientating of economic activity towards reuse of materials, designing out waste, and regenerating natural systems. There is also the inclusion of a more sustainable built environment, renewable energy systems, and new urban mobility systems in the vision for the circular city (Ellen MacArthur Foundation 2017). Current research on the topic of the CC primarily focuses on the technical and economic aspects of CE transitions in cities, with growing contributions through both academic and professional research contributing to clarifying what a CC entails. Marin and De Meulder (2018 pp.3) acknowledge that "explorations of the 'circular city' as a socially, environmentally, and economically resilient city supported by circular economies are urgent but have only just begun".

In the context of the city, spatial planning is used to shape urban development and align the actions of individual actors towards a common objective. Strategic urban planning is characterised by its use of vision documents in combination with spatial or land use plans which align land uses within the city towards a desired spatial objective (Needham 2006). It can further be described by establishing a broad strategic direction which coordinates 'changes in degree' which in time lead to meeting the desired planning outcome (Bryson 2009). This planning is a form of 'strategic market transformation' that allows for radical transformation of places, the creation of new places,

and the creation of new markets of land development, employment and economic investment (Adams & Tiesdall, 2012).

Circular city development strategies specifically focus on transforming the economy and functions of the city, and similarly will shape the places within our cities and the nature of land development. The circular city as a concept does not currently focus on space as a location but rather the organization of space, with the effects of a circular transition in a 'place-based' focus not a large consideration of existing monitoring frameworks and literature (Van den Berghe & Vos 2019, Marin and De Meulder 2018). The circular city provides the actions required of businesses, governments, and people to meet its ambitions, and provides a vision for the sustainable economy of the future. Notwithstanding, the deployment of circular strategies at the level of the city do not explicitly envision the outcome of the circular transition upon our neighbourhoods in spatial terms. In creating places in the city, these strategies and policies will shape the behaviour, choices, and actions of people, as well as governments and decision makers when planning our neighbourhoods (Adams & Tiesdall 2012, pp.201).

1.2 Research Aim

The transition to the circular city will affect how people live, work, and move within the city. The transition to a CE and its implementation in a circular city will impact upon the way our cities look and function. The CC as a concept will translate down to the 'circular neighbourhood', spaces which house the residents of the city. Recently, there are examples of 'top-down' (policy and strategic documents from city governments) as well as 'bottom-up' (local project-based initiatives) transition strategies for circular development. This research will look to focus on neighbourhood development as an element of the circular city, and the implementation of circular strategies and their envisioned impact on the neighbourhood.

1.3 Research Question

The central research question this thesis aims to answer is:

- *How is the circular city interpreted at the scale of housing and the neighbourhood?*

The objective of the research is to understand how circular city strategies will eventually shape *how* people live in the circular city.

The structure of the research question is aimed at first identifying how residential and neighbourhood development is addressed in circular city transition documents – *how does a circular economy transition in the city address residential neighbourhood development?* City strategies that involve a transition to a circular economy and their relevant plans will be analysed to identify how, or if, residential development is included as part of their vision. Further, the research question is aimed at analysing how the circular city as a concept is understood at the scale of housing and the neighbourhood. The question is used to explore what the circular city entails and what this means for how people live. Topics of material reuse, urban mobility, liveability, and the built environment are explored, with these elements all being relevant to the

housing and neighbourhood dimension of the city. The research sub-questions are outlined below:

- *How does a CE transition in the city address residential neighbourhood development?*
- *How will residential land uses in the city be shaped by Circular City strategies?*
- *What does Circular City implementation entail for housing?*
- *How do bottom-up approaches to the CC reflect the circular 'principles' contained within CC Strategy documents?*

This thesis will use desk research to examine and interpret various circular city strategies to answer the research question. Research into relevant cases including their city policies, strategic plans, and project reports will be carried out through a document analysis - consistent analysis of relevant texts aimed at developing insights as to how the broader concept of the circular city translates to the level of the neighbourhood.

As discussed further within the literature review at Section 2, existing academic research on the CC relates to the micro- (products/businesses), meso- (buildings) and macro- (regional) scales of the circular economy (McDonough & Braungart 2010, Pomponi & Moncaster 2017, de Jesus et al. 2018), with this thesis looking to explore the implementation of the CC concept at the scale of housing and the neighbourhood between the meso- and macro- scales.

Finally, the scope of this research is targeted at countries that are part of the European Union with some international examples of globally significant cities who engage in circular city strategies, noting this research will traverse the international, national, and local scales.

1.4 Scientific and societal relevance

1.4.1 Societal Relevance

The research is of relevance currently with a number of businesses, local and national governments, and international organisations initiating plans for a transition to a circular economy. Growing urbanisation trends and environmental challenges are the key drivers for cities in particular to begin to plan for a more sustainable future, with the circular economy being the guiding idea for this shift (Prendeville et al., 2017). The societal relevance of this research is primarily through a new analysis of what the CE transition means for how people live in our cities. The research will analyse how the neighbourhood is addressed within the circular strategy documents prepared by various cities and how the vision for a circular city is interpreted at the scale of the neighbourhood – between a research gap identified within the established meso and macro scales of CE research.

Further, the implementation of circular city strategies is expected to be realised over the coming years noting the relatively new topic of 'circularity' as a sustainability strategy. The practical implementation of cities engaging in circular transitions will impact upon, amongst other things, how people live, their neighbourhoods, and their homes. The translation of strategy and vision documents to concrete action will become evident in the way people live if visions for a circular

city are implemented. This requires an exploration of how individuals' lives could be affected by the circular city.

1.4.2 Scientific Relevance

While current research on the topic of the CC primarily focuses on the technical and economic aspects of circular economy transitions in cities, there is need for research to contribute to clarifying the identifying and spatial characteristics of the CC. Marin and De Meulder (2018 pp.3) acknowledge that "explorations of the 'circular city' as a socially, environmentally, and economically resilient city supported by circular economies are urgent but have only just begun".

The relevance of this research particularly is to place an emphasis on one particular aspect of the urban environment – the neighbourhood as a unit of the city, and how it is affected by transitions to a CE. These sustainability transitions do not only involve a reorientating of economic activity towards reuse of materials, designing out waste, and regenerating natural systems. There is also the inclusion of a more sustainable built environment, renewable energy systems, and new urban mobility systems in the vision for the circular city (Ellen MacArthur Foundation, 2017). This research will look to explore further into what the CC involves and how this is interpreted at the scale of housing and the neighbourhood

1.5 Structure of the thesis

This introduction provides a summary of the CE as a goal for sustainability strategies of various governments, businesses, and organisations across the world. Further, the research questions are stated and methodology of how to answer them has been detailed. Section 2 of this thesis contains a literature review of the academic and professional knowledge in the domain of the circular economy, circular city, and spatial planning and identifies relevant concepts to serve as a background for the research, Section 3 contains a theoretical framework of the related concepts, operationalization of terms and concepts, and adaptation of an existing conceptual framework to be applied to the research topic. Section 4 contains methodological choices to collect and analyse data in accordance with the research strategy, which comprises document analysis, and expert interviews using the Delphi method. Following from this, Sections 5 and 6 contain the analysis carried out examining each city strategy against the conceptual framework to answer the research questions, and triangulation of conclusions from the document analysis through expert interviews. Finally, Sections 7, 8 and 9 contain the main findings of the research and provide conclusions related to the circular neighbourhood as it will be expressed from the vision documents analysed. Reflections on the research process and recommendations for further scientific research are provided in Section 10.

2. Circular City – Concepts and Theoretical Perspectives

The literature review in this section has been structured to identify current concepts within the topic area from larger to smaller conceptual and geographical scales. The review introduces the concept of the Circular Economy as currently understood and its development as a solution to global environmental challenges, specifically the use of scarce raw materials and the impact of current economic and production trends upon the natural environment. Following this, the application of the CE concept at the level of the city is explored, with reference to international Action Plans and existing research related to circular city strategies. Existing Circular City characterisations and research frameworks are detailed, with reference to their criticisms and adaption throughout recent years. Following this, strategic spatial planning as a means for envisioning and enacting change in urban environments, and its relationship to the organisation of the circular city is discussed, and finally the existing indicators and tools used to monitor and implement 'circularity' in a city are presented.

2.1 The Circular Economy as a solution to resource scarcity

The UN Sustainable Development Goals laid out by the 2030 Agenda for Sustainable Development (United Nations 2015) provide a blueprint for future sustainable development across 17 goals that span ending poverty, improving health and education, reducing wealth inequality and spurring economic growth while addressing climate change and preserving the natural environment. Linkages to the core concepts of the CE are evident in explicit goals related to affordable and clean energy (Goal 7) and responsible consumption and production (Goal 12). Sustainable cities and communities (Goal 11) are supported by the UN New Urban Agenda and reflect the necessity of cities to improve their current resource consumption trajectories and change how they fundamentally grow and are organised.

Globally, businesses, local and national governments, and international organisations have begun initiating plans for a transition to a circular economy. Growing urbanisation trends and environmental challenges are the key drivers for cities in particular to begin to plan for a more sustainable future, with the circular economy being the guiding concept for this shift. The United Nations' New Urban Agenda adopted in 2016 placed a focus on sustainable urban development at the local level. It identifies the growth of the world's urban population and the transformative nature of cities as challenges to global sustainability issues such as natural resource use (UN Habitat 2017). Sustainable urban development is the central commitment of the New Urban Agenda, with the circular economy's role in cities specifically mentioned as a solution to the issue of sustainable resource management (UN Habitat 2017, pp.19). At the European level, the EU has adopted a similar approach in its focus on future sustainable development.

The European Green Deal and its action plan seek to reach climate neutrality for the EU by 2050. The shift to a circular economy is proposed as the solution by which extractive industries will be transformed to reduce their impact upon resource extraction and processing of minerals (European Commission 2019). The Urban Agenda for the EU and its action plan focus on waste management, the sharing economy and resource efficiency (European Commission 2015). On the National level in the Netherlands, the goal for a completely circular Dutch economy by 2050

is guided by the goals of ensuring production processes use raw materials more efficiently, use renewable materials where raw materials are needed, and develop circular production methods and new products.

As reflected by the goals of the UN, EU and Dutch National government, the concept of the circular economy as established in existing academic research focuses on the reuse of resources – materials, energy, and waste in the production of goods/services (McDonough & Braungart, 2010), and while there are many varying definitions for the concept, a common element is the improved management of resources to "overcome the contradiction between economic and environmental prosperity" (Pomponi & Moncaster 2017, pp.2). It is established as the counter to the current linear economic model of 'take-make-dispose' whereby materials and energy are extracted to create products, and then sold and used, before being disposed of as waste and removed from the product value chain (World Economic Forum 2018). The circular economy instead seeks the retention of resources in the production of goods by closing the 'material loop' and minimising the loss of value through waste. An analysis of 114 definitions of the circular economy conducted by Kirchherr, Reike and Hekkert (2017 pp.229) provides the following comprehensive definition:

> *"A circular economy describes an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations."*

The primary goal of the CE is achieving a fundamentally sustainable global economy, and the transition of current economic trends towards a circular model provides a holistic approach to development that encompasses the social, environmental, and economic pillars of sustainability (Vayona & Demetriou 2020). The shift away from dependence on cheap and easily accessible materials and non-renewable energy towards an economic model that "restores and regenerates natural capital" is seen as an opportunity to create economic value more sustainably (Ellen Macarthur Foundation 2015). Such circular business models have been categorised as either 'slowing, closing, or narrowing' the loop of materials and waste in production, by designing for a longer product life, recycling materials after their use, or using fewer resources per product, respectively (Bocken et al. 2016).

The concept of closing the loop of material use aims to make the most of the residual value of resources or collecting waste materials and resources to modify them and create new value (Paiho et al. 2020). As such, the environmental impacts of the CE model can be described by its reduction of finite resource extraction from the earth in combination with a reduction in waste by extracting value from materials beyond that of our current production models. Further, its economic impacts concern moving towards more sustainable industries and production methods, thereby creating value where otherwise there was waste, while also fuelling innovative employment sectors.

The social dimensions of the CE, while underrepresented in literature are still being examined (Moreau et al. 2017, Vayona & Demtriou 2020, Lekan & Rogers 2020). They encompass reducing reliance on resource extraction and goods produced globally by developing countries and impoverished peoples globally, and introducing new business models such as the 'share economy' and promotion of products-as-a-service to counteract current product consumption trends. There is concern for the need to establish labour at the core of a future economic model, being a renewable resource that is potentially susceptible to exploitation in current CE conceptions (Moreau et al. 2017). Socially inclusive forms of urban economic development such as the 'diverse economy' that seek to generate value for people and the planet rather than business are described as an integral part of the urban economy in a CE (Lekan & Rogers 2020). These economies involve diverse social actors and community-based organisations and support a localised 'closed loop' economy with businesses such as craft spaces, repair cafes, food sharing, local food production, litter picks, clothing swaps, and makerspaces. Lekan & Rogers (2020) raise concern with the digitisation of these types of businesses required within a Circular City, and the impact of increasing reliance on technology in the CE through social media or mobile apps, with the risk of exacerbating problems of digital illiteracy and citizen participation.

As described above, the CE as studied in existing academic literature spans beyond its origins as a new model to overcome linear production and consumption, and associated recycling and reuse of waste and material in the economy. Its exploration has focused on the positive environmental significance of such an economic shift, opportunities for innovative business models and employment sectors, and creation of synergies across various sectors to mitigate impacts upon the natural environment (Merli, Preziosi & Acampora 2018). New economic models such as the performance economy – providing products as a service to reduce reliance on manufacturing but increase repair and recycling, or the sharing economy – sharing goods ad services between people to reduce consumption do not specifically aim to reduce impacts on the environment but have been described as aligning with CE principles (Taranic et al. 2016). The societal and economic dynamics of a CE and social implications of this sustainability transition are still being developed as well as raising institutional changes required to support the model.

Spatially, the various scales of existing research in the realm of the circular economy relate to the micro-, meso- and macro- scales, being a focus on the individual actor/business scale (McDonough & Braungart, 2010), building scale (Pomponi & Moncaster, 2017), and regional scale respectively (de Jesus et al. 2018). Existing macro level research in CE implementation in the city and research on the implementation of circular city strategies concerning neighbourhood development is growing, as discussed in the following section. The actions conducted at the macro level for a transition to the CE in the city impact upon the spatial organisation of cities, and in turn, impact upon how and where people within cities live.

Early research related to the implementation of a circular economy in the city largely concerned the physical elements of the built environment including technical analysis of construction methods, building materials, life cycle assessment and material flow analysis of urban development (Pomponi & Moncaster 2017). Policy analysis related to the circular economy transition in the built environment has addressed regulations and directives and their implementation to promote reuse of construction materials (Henrotay et al., 2017), or other circular practices for the development industry. This research identified the levels of material and

resource consumption within the industry and recognised the need for policy tools to transition these practices towards a more sustainable approach, through circular economy principles.

2.2 The Circular City

The 'circular city' as a concept can be broadly identified as the incorporation of the principles of a circular economy across all the 'functions of the city' (Ellen MacArthur Foundation, 2017), but its precise definition is still being contributed to and built upon (Prendeville et al. 2018). The implementation of circular economy strategies at the level of the city has been analysed through various frameworks developed over recent years (Marin and De Meulder 2018, Prendeville et al. 2018, Gravanguolo et al. 2019) and provides analytic frameworks to contribute to the body of research into how the circular economy emerges when applied to the 'spatial territorial dimension'.

While building and renovation amount to 32% of global energy and 40% of energy and resource consumption in the European Union (O. Lucon et al. 2014, European Commission 2019a), the circular city concept extends beyond built environment efficiency targets such as those adopted by the EU for closing material loops in the construction sector. While the circular economy and circular business models within the urban context are integral parts of the circular city, the concept broadly concerns itself with the "regeneration and renewal of complex urban ecosystems" (Williams 2019a pp. 2759) involving closing material loops across building, water, waste, food and energy sectors; prioritizing and generating new innovative industries and jobs; improving social and educational opportunities (Ferreira and Fuso-Nerini 2019); and co-locating land uses to support circularity long-term (Williams 2020). The transition to a CE in an urban context must consider the city and its functions in their entirety, with the culmination of all actions decreasing its impacts upon the natural environment and global climate change (Boeri et al. 2019).

Cities and their ability to serve as agents of an economic transformation are presented as key 'centres for change', largely due to their ability to regulate and enforce new standards with respect to resource use, emissions or waste, and citizen or business behaviour. The city acts as a "nexus that connects and is shaped by State, Market, Societal and Geospatial events and activities, and is constantly evolving within ever-changing contexts which influence its development" (Jacobs 2015). In the context of the CE, the implementation of circular design and actions towards a CC must similarly involve nexus solutions that reflect the nature of cities themselves – integrated and spanning multiple resources and functions (Williams 2019a). Municipal governments are pointed out due to their ability to use regulatory tools to enact change. They are capable of utilising policy levers across various realms to begin implementing the CE in a hierarchical way or 'top-down approach' (Ellen Macarthur Foundation 2019). These city governments are in a position to create visions, engage with stakeholders across all sectors, incentivise or regulate behaviour, manage the physical environment, and finally 'lead the charge' through organisational change in governance processes themselves for example in procurement (Ellen Macarthur Foundation 2019, World Economic Forum 2018). Further to the ways in which cities can enact change towards a CC, the important areas in which these actions can be coordinated reflect directly from the CE conceptualisation previously described. Their built environment being the physical make-up of the city, buildings and roads; energy systems including heating and cooling; mobility and transport

systems; and the bioeconomy of food and waste are all highlighted areas for opportunity (ENEL 2018).

Academic research relating to the implementation of the CE at the level of the city, and the concept of the 'circular city' has largely involved looking to define the concept, carrying out an analysis of case studies, or studying cities engaging in a transition to build broader approaches for its implementation (Boeri et al. 2019, Carriere et al. 2020). It also has identified common elements and established analytical and methodological frameworks for these cases (Prendeville et al. 2018, Ferreira and Fuso-Nerini 2019, Gravanguolo et al. 2019). Prendeville et al. characterise the concept of the circular economy as "over-hyped, scarcely investigated and therefore as yet ill-defined", and identify its focus largely on business development and economic competitiveness (2017, pp. 172), while contributing to the discussion of the circular city through an analysis of six European case studies aiming to assist in clarifying the definition of the circular city. Existing literature on the circular city has "inquired into the role of local stakeholders in promoting and practicing the CE, [but] the extent to which it becomes mingled with wider urban development processes has received far less attention" (Keblowski et al. 2019 pp. 143).

City level initiatives including development strategies, action plans, procurement policies, and circular project funding have been identified in recent literature, with the EU's Climate KIC Circular City Project identifying 130 circular city initiatives across the world in the realms of city strategies, urban refurbishment, public procurement, and utilities and waste (Climate-KIC 2018). Circular city development strategies specifically focus on transforming the economy of the city, which will go on to shape the places within our cities and the nature of current land development models. The circular city as a concept does not currently focus on space as a location but rather the organization of space, with the effects of a circular transition in a 'place-based' focus not generally considered in existing monitoring frameworks and literature (Van den Berghe & Vos 2019, Marin and De Meulder 2018). The CC as a concept provides a guide for the actions required of businesses, governments, and people to meet its ambitions, and to create a vision for the sustainable economy of the future. In creating places in the city, CC strategies and policies, just like other urban planning processes will shape the behaviour, choices, and actions of decision makers when planning our neighbourhoods (Adams & Tiesdall 2012, pp.201).

The CC model focuses on the reorganisation of the various functions of the city to mimic natural systems where there is no waste, through the incorporation of the principles of the CE to close material, energy and waste loops within the city (Fusco Girard & Nocca 2019). Activities that can be carried out to close material loops in the city are key to driving circularity, but face difficulties in implementation including with respect to society and culture, institutional capacity, regulation, economic incentivisation, and political challenges (Williams 2019b). Similar categorising of barriers to implementation have identified that these factors do not act in isolation of one another but rather "*form a complex web of interconnecting critical factors"* that hinder or support implementation of CE transition actions (Russell et al. 2020). Further, environmental challenges such as spatial scarcity in cities hindering adoption of circular activities, and technical/design challenges surrounding the altering of current systems and infrastructure within a city towards circular systems are also barriers to a transition to the CC, with transformation tools such as nature-based solutions identified as being able to solve some of these barriers and accelerate the shift to the CC (Williams 2019b, Katsou et al. 2020). Models and frameworks for the CC have

been developed to assist research and implementation of the concept in recent years. These frameworks seek to encompass the varying elements of urban environments and the actions and principles required to transform them towards a regenerative CE model.

2.2.1 Circular Economy for the City

Frameworks aimed at cities have been formed to assist sustainability transitions by providing blueprints for cities and government bodies to develop strategies, action plans, and policies that serve to make incremental changes to achieve a larger sustainability goal (Carbon Neutral Cities Alliance and C40 Cities 2020). In response to growing movements towards a CE at the level of international bodies, national governments, cities and business, a number of frameworks have emerged that conceptualise the CE for its implementation. The Ellen Macarthur Foundation's ReSOLVE Framework, one of the first examples of such a conceptualisation (Ellen Macarthur Foundation 2015) was created to provide business actions that related to the principles of the CE. The framework presented the following actions: *Regenerate, Share, Optimise, Loop, Virtualise* and *Exchange.* Each with a focus on reducing resource consumption, extracting value from production chains for as long as possible, designing out waste, and mitigating ecological impacts, the actions are characterised by a number of examples. The shift to renewable energy and materials to return biological resources to the earth, reducing disposal of products and engaging in a 'share economy', increasing efficiency of current production chains, close material 'loops', push for virtual products, and repair of products were all identified as fundamentally 'circular' changes.

Whilst a focus on business actions and shifts in economic activities are the key targets of the ReSOLVE framework, cities too are pointed out as potential 'pilot' areas for implementing the CE. Urban regions are presented as satisfying all elements of the framework, with the built environment and infrastructure capable of being constructed from recycled materials and planned for reuse, the city's functions to be powered with renewable energy, and waste recovery systems extracting maximal value from the output of cities (ARUP 2016). Further, the residents, businesses, and governments of our cities are positioned to participate in the share economy, reduce their resource consumption, and engage in the CE at the ground level (Ellen Macarthur Foundation 2015). Whilst being one of the first frameworks that links the CE transition to our cities, following its introduction it has been adapted beyond its original scope to further circular city discourse (Prendeville et al. 2017), and even critiqued as 'inadequate' when applied to the city (Williams 2019a).

Shortcomings of the ReSOLVE framework when applied to the urban context have been pointed out, acknowledging that it was not designed for the purpose of application to the city. The city's complex urban systems and diverse range of actors are distinguished from the industrial and commercial enterprises within a single sector who can shape their processes and business models towards a CE model (Williams 2019a pp.2750). Further the framework focuses primarily on production methods and products themselves but does not consider cities as resource consumers, and the resulting patterns of consumption that result from how our cities function. Further, land development processes are not considered not their impact on resource

management and infrastructure as a resource supplier (Williams 2019a pp.2751-2754). Adaptation of existing environments and the scale at which resources circulate also requires translation from urban metabolism monitoring to applications which can create circular areas within a city.

2.2.2 Circular City Frameworks

Following the focus on implementation of the CE at the scale of the city, the ReSOLVE framework has been subject to further elaboration, development, and adaptation to be applied to the realm of the built environment and city to support research and implementation in the field of the CC. Direct applications of the framework to the built environment have interpreted the existing ReSOLVE actions directly to the elements of buildings that can be circularly adapted to fit the actions (Iyer-Raniga 2019). The interpretation of the six circular actions to the built environment in these applications focuses largely on the building (meso) scale of the city and specifically: construction methods, management of buildings throughout their lifecycle, and designing for demolition and deconstruction that maximises value retention during a building's end-of-life processes (Iyer-Rainga 2019, Ajayebi et al. 2020). This is consistent with a common feature of CE indicators which identifies a focus on improving resource efficiency by diverting material away from landfill or social impacts (Carriere et al. 2020).

These applications of the ReSOLVE framework for circular actions are predictably linked to methods such as material flow and life cycle analysis discussed previously given their attention aimed specifically at the physical built environment. Ferreira and Fuso-Nerini (2019) in their development of the framework devise a Circular City Analysis Framework (CCAF) that identifies key CE concepts relevant directly to the city across its 'intrinsic properties and sectors'. While ReSOLVE, and material analysis methods have a role in monitoring the 'circularity' of the city and quantifying the consumption of energy and materials, the resources of a city and their relationship to locality, together with city's demography are relevant to its transition to a CC as these elements convey the city's context and identity. Infrastructures of the city concerning mobility, industry, housing, and offices also determine a city's dynamics, with these having a substantial impact in circular terms within the city context. The circular city is identified as adaptable, embracing new technologies to come (digitalization, shared mobility, renewables) whilst also promoting land use synergies and closing of material flows.

Prendeville et al (2017) adapt a framework to map six cities that have engaged in a circular transition, identifying a lack of consensus on what the circular city constitutes, and a need to further untangle the 'how' and 'why' of the concept when applied to the city. This framework is based on ReSOLVE, but was similarly adapted to encompass urban 'activities' rather than business actions. Further to the resource consumption associated with the built environment, 'top-down' and 'bottom-up' initiatives are presented as instances of CE implementation. These initiatives span realms of political leadership, building adaptable future visions, experimental approaches (living labs), development of contextual knowledge regarding resource use, and engaging with diverse stakeholders. This framework characterises a city that practices CE principles as one that engages in closing resource loops, whilst in partnership with stakeholders

– citizens, community, business and knowledge stakeholders, to realize its vision of a future-proof city.

2.3 Spatial Planning & Neighbourhood Development in the Circular City

The section below details the role of spatial planning in creating strategic visions to inform transformations in the city, and as a regulatory tool in managing land uses within cities. It links spatial planning to sustainability transitions in urban areas such as the concept of the CC, and finally neighbourhood development in spatial planning and the role of neighbourhoods in transitions to the CC.

2.3.1 Spatial planning as a vision-making & land-use regulation tool

The spatial organisation of the CC is a recent topic of exploration within academic literature, with urban planning specifically identified as a 'technical enabler' for the circular transition, noting its ability to guide the development of buildings, infrastructure, and public space towards circular models, creating markets and spaces for circular activities and experimentation, plan for synergies amongst different land uses and urban processes to create localised material loops, and finally generate demand for circular activities and products through conditions place of new urban development (Paiho et al. 2020, Williams 2020).

Spatial planning is used to shape urban development and align the actions of individual actors towards a common objective in spatial development. Strategic urban planning is characterised by its use of vision documents in combination with spatial or land use plans which align land uses within the city towards a desired spatial objective and establishes a broad strategic direction which coordinates 'changes in degree' that, in time, lead to meeting the desired planning outcome (Needham 2006, Bryson 2009). The effort of cities to transition to a circular city involves a shift to circular urban development models and the associated socio-ecological transformation of current urban systems, with spatial planning used as the tool for regulating local development (Williams 2020). Spatial planning as both a vision-making and land-use regulation tool spans the realms of "design-oriented physical planning and policy-oriented socioeconomic planning" (Gleye 2014), and its use in delivering transformation at the level of the city is a key element of the circular city.

In the European context, strategic forms of spatial planning re-emerged in the early 21st century in local and regional government practice following an emphasis on urban renewal projects and development structure plans of the 1990's (Healy 2004, Buitelaar 2010). Strategic spatial planning allows for the coordination of public policy in specific localities, seeks to make urban regions more economically competitive, seeks to shape the urban form and relationships whilst promoting overarching objectives such as sustainable development, and can be aimed at solving problems of resource and wealth equality within regions (Healy 2004, pp.45). In economic terms, strategic planning can also be described as a form of 'strategic market transformation' that allows for radical transformation of places, the creation of new places, and the creation of new markets of land development, employment and economic investment (Adams & Tiesdall, 2012).

Across northern Europe (Germany, Netherlands, and Scandinavian countries) and specifically in the case of the Netherlands, spatial planning systems are generally characterised by their ability

to influence development outcomes beyond that of more passive planning systems which carry out planning through land-use control carried out via the zoning of land and issue of building permits. These 'integrated and comprehensive' planning systems involve large scale development of land; inclusive of private, public, and community stakeholders; and have the ability to ensure timely and cohesive delivery of planned visions through the use of active land policy (Buitelaar and Bregman, 2016). As an example of 'active land policy', this form of spatial planning involves the purchase of land by a public government body (for example, a Municipality) and legal implementation of a spatial plan. This is followed by the carrying out of works to prepare the land for development prior to recouping costs through the sale of land for development, with the Municipality's infrastructure and land costs recovered from this sale and through public value capture of increased land prices from 'upzoning' of land through a land use plan (Buitelaar, 2010 pp.351).

Following the global financial crisis of 2008, the vulnerabilities of active land policies such as that characterising the Dutch planning system were uncovered. Specifically, the impact of market fluctuations and economic pressures upon public bodies carrying out land use plans, and subsequently burdening themselves with initial financial risk. Public-private partnerships resulted in Municipalities having to bear the risks and costs of development following private parties financial failure (Buitelaar and Bregman, 2016, pp. 1290). Further, economic factors such as increased land values/rents make it difficult for the Municipality to engage in purchasing land to implement its plan. Finally, the trend of large greenfield developments which make the Dutch active land policy viable are less attractive when applied to inner-urban or former business/industrial sites. Smaller, more fragmented parcels of land require more funds to purchase, are generally more valuable than rural land (for example transit accessible, inner-city land), and in some cases require remediation to allow for their change in use (Buitelaar and Bregman 2016).

In contrast, 'passive land use policies' influence spatial development with no Government (public) initiative for land to be developed. Through a combination of issuing planning permissions, zoning and subdividing land, and steering development with policy implementation, envisioned planning outcomes of a Municipality or Government are not carried out by the authority but rather development is guided by the 'set of rules' surrounding urban development (Needham 2014). Outcomes are guided by the issue of planning permission for the use of land, in accordance with a previously established planning policy, building code or zoning regulation. In this way, the planning authority can coordinate the actions of market actors by granting or denying permission for certain forms of development. Needham (2014 pp.126) describes examples of forms of development that require planning permission including: constructing a building, carrying out earthworks, using land outside of that permissible by a land-use plan, altering or demolishing a heritage building, or demolishing a building. These activities can be assessed against land-use plans, building regulations and other planning policies when deciding to issue planning permission. As discussed further within this literature review, current understandings of the CC and its implications with respect to spatial planning as a tool for shaping our cities involve the shaping of the physical built environment in terms of resource use, but also the co-location of compatible land uses to create local material loops, and re-use of materials in our cities.

2.3.2 Spatial Planning for the Circular City

The vision-making foundation of strategic spatial planning is pertinent to the CE transition in urban regions, towards a circular city. It contains a major ability to shape collective effort to re-imagine an urban space or territory and implement change through the prioritisation of land and infrastructure investment, conservation measures, and land use regulation (Healey 2004). While identified as a more radical form of spatial planning than traditional urban planning (land use plans or master planning), this is because strategic visions provide a different output that challenges and transforms the existing social order rather than maintaining it (Albrechts 2015). A circular transition requires the altering of every component of our urban regions with respect to waste and resource management, business practices and economic development, governance, and our built environment (World Economic Forum 2018), and as such the CC is see as a goal born from strategic planning and vision making.

Keblowski (et al. 2019) identify a missing link between academic research and the use of the CE to form wider urban development processes in our cities, with current CC discourse focused largely on best practice examples of circular projects and 'showcasing' cities who have planned a transition. Van de Berghe and Vos (2019) suggest that a problem with sustainability transition attempts such as the shift to a circular city, is that they place efforts primarily in policy making with less focus placed towards implementation. They identify the CE as a promising model which is an example of both 'top-down' (government policy directed) and 'bottom-up' (business or individual actor initiated) approaches to such a transition. Spatial planning and the future design of the city must therefore focus on organization of space through governance noting the need for internalization of remanufacturing and tying green skills with green activities in our cities, as well as promotion and encouragement of circular practices. Circular area developments, Van de Berghe and Vos (2019) claim are making cities less circular because functioning is not a consideration of their implementation.

Loorbach et al. (2016) confirm that policy making is a primary focus of sustainability transitions in cities, but the implementation of change through policy (structured top-down approach) can fail as cities are complex adaptive systems that are self-organising and that formal policy-making processes tend to target sector-specific problems that are 'solvable'. They state that "the problems regular policies try to solve, such as pollution, emissions, and congestion, are often only the symptoms of underlying systemic problems" (Loorbach et al. 2016 pp.9). Conversely to Van de Berghe and Vos (2019), it is asserted that cities need to transcend the barriers of focusing only at the spatial scale as global sustainability issues do not always relate directly to actions at the 'street level'. A multiscale approach to transitions through bottom-up initiatives and innovations connected and interacting with governance structures and 'top-down' policies are key to accelerating solutions to sustainability problems such as that presented by the concept of the CC.

Spatial planning as both a vision-making tool in the case of strategic spatial planning, and as a regulatory tool in the case of land use planning, echoes the requirement for both top-down and bottom-up approaches to sustainability transitions such as that towards a CC. Beyond the idealisation of the cities functions within a closed material loop, the management of land through spatial planning is critical but has largely been ignored in current CC conceptualisations. Land use and the physical urban form directly shapes resource consumption patterns with respect to energy, mobility, and the broader functions of the city's actors which are targets of the CE

(Williams 2019b). Further, land is itself a resource that offers value economically, as well as in natural value in processes that provide ecosystem services or societal benefits.

The most commonly identified link between the CE and planning to transform the city to a circular state is the creation of space in urban regions to co-locate low-value circular activities (Williams 2020, Van de Berghe and Bos 2019, Williams 2018). Different types of industries, recycling and remanufacturing facilities, urban farming uses, and waste processing must all be close in proximity to reduce the distance between producer and consumer and localise material 'loops' (Williams 2019b), a critical element of the CE, and spatial planning is instrumental in addressing unsustainable resource consumption through land uses (Williams 2020, Turvu & Gillie 2020). The reintroduction of low-value land uses within urban regions to localise material and waste loops directly contravenes existing economic land use patterns in cities across the world, whereby economic competitiveness and success reduces available urban land by increasing land value through speculation (United Nations 2017).

Boeri et al. (2019) identify the spatial requirements of a circular urban vision, with an emphasis on the creation of resource loops in a clustered perspective to overcome current separation trends between urban and peri-urban areas. They present the concept of 'resilience corridors' able to connect different parts of the city in resource loops. Urban and peri-urban areas; historic downtown neighbourhoods and peripheral areas, economic centres and satellite areas all 'trading' materials and waste in a circular manner. This is reflected by Williams (2019) who suggests that in addition to providing space for circular activities, the urban form of our cities must also support material loops through a mixture of land uses to enable urban symbiosis, and the use of adaptable infrastructure to meet changing needs and that the following circular urban renewal will result in a societal transformation towards CC adoption. Further, the creation of innovation hubs, being nodes of innovation where specific circular actions can take place and the facilitation of entrepreneur and stakeholders in the co-creation of circular economy processes are a feature of the resilience corridor resulting in the spatial implementation of a transformative living lab that is exemplary of the circular city concept through a focus on circular design, its urban metabolism, and circular employment promotion (Boeri et al. 2019).

The management of land in the CC is presented as a critical solution to addressing global urban trends that present problems of sustainability. Shrinking cities and population decline as a result of global economic and national demographic trends, and foreign and corporate acquisition of land after the global financial crisis of 2008 transformed the pattern of land ownership and land use in many cities (Williams 2018). High value activities within the city such as luxury residential dwellings or commercial space became prominent land uses, reducing space for lower value activities such as industrial production or green space (United Nations 2017). These 'lost' land uses are essential for the functions of a circular city which include the local production of resources, recycling of waste, and regeneration of the urban ecosystem. Further, speculation of land and global investment in land and housing as a commodity has resulted in their 'financialisation', disconnecting them from their social and environmental functions within the city (Williams 2018). Land scarcity increases the value of land and property, resulting in vacancies where there would otherwise be oversupply, and vacancies prevent the re-use and promote underutilisation of the resource. Increase land values lead to urban densification, the loss of green and blue infrastructure, and finally critical urban ecosystem services.

The management of land in the CC requires reorientating value towards circular land uses (including industrial uses, green spaces, and urban nature) with urban ecology specifically being critical in mitigating flooding, heat, pollution, declining biodiversity and soil degradation in urban environments (Langergraber et al. 2020). Further, spatial planning directly affects the environmental impacts of urban systems with respect to policy and area design and the environmental performance of buildings, land uses and city residents (Petit-Boix & Leipold, 2018).

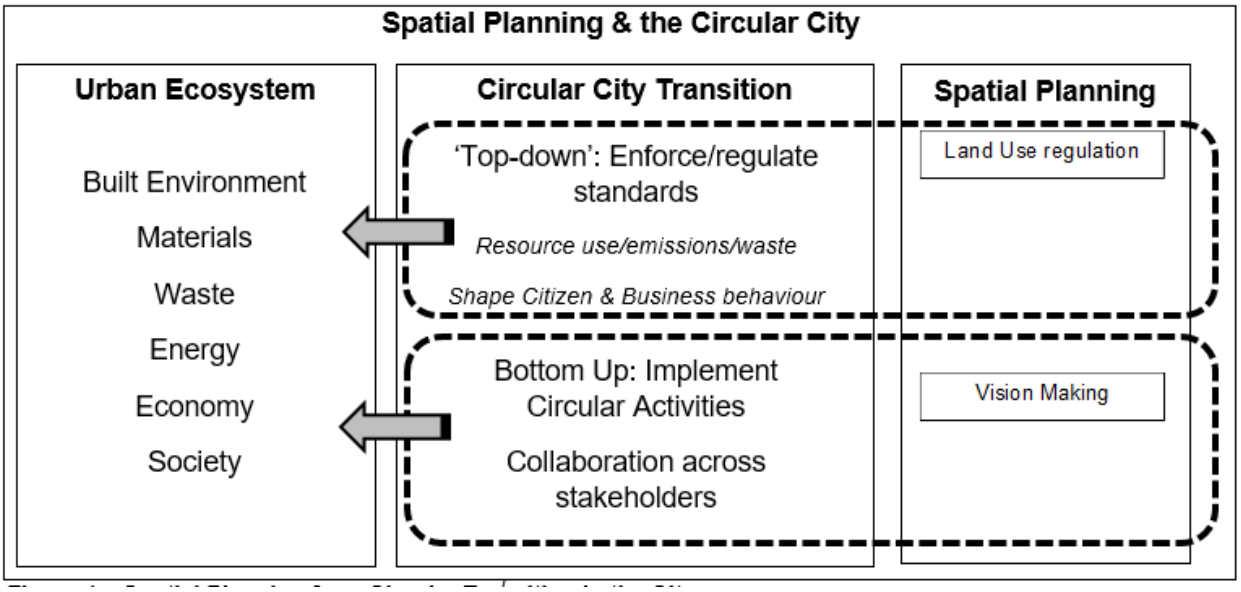


Figure 1 – Spatial Planning for a Circular Transition in the City

2.3.3 The Circular Neighbourhood

Common amongst existing research into the CE at the level of the city is the opportunity for the transition to be stimulated by experimental approaches whereby a certain locality or part of the city becomes an innovative 'laboratory' where the concept is implemented and trialled in practice (Nevens et al. 2013, Boeri et al. 2019, Prendeville et al. 2017, Santonen et al. 2017, Circular City Funding Guide 2020). Santonen et al. (2017, pp.8) characterise the urban living lab as a "real life environment where various stakeholders from public-private-people partnerships take part in Living Lab activities in a systematic way by using various approaches, instruments, methods, concepts, conceptualizations and tools". This definition is reflected in further reports of CC projects within the city as catalysts for broader change, which recognize that the requirement for localised spatial links amongst material producers, consumers, and waste production is critical to maximise the circular functioning of the city, whether through 'resilience corridors', living labs, or urban transition labs.

The neighbourhood concept was a prominent characteristic of urban planning in the twentieth century, with early urban design and architectural principles of western industrialising countries centred around providing housing for workers and their families, separate from places of employment (Patricios 2002). The neighbourhood designs of the twentieth century evolved from the concept of the garden city model envisioned by Ebenezer Howard where the city was divided

into smaller 'wards' each designed around a central green open space and containing various forms of residential accommodation (Howard 1902). Definitions of the 'neighbourhood' as an urban planning concept have evolved from these earlier conceptions. From a focus on spatially based attributes associated with clusters of homes, sometimes in conjunction with other land uses (Lancaster, 1966), claims that it is beyond definition but regardless identifiable to the layman (Galster, 2001), and further a broader emphasis on the neighbourhood as a relational component of a larger region (Hartman, S. et al. 2011). Urban development with respect to the neighbourhood has been characterised as a "*self-organizing system in which natural constraints and institutional controls (land-use policies) temper the way in which local decision-making processes produce macroscopic urban form"* (Verburg et al. 2004 pp.668). Interactions between neighbourhoods that shape urban growth include economic interactions of consumers, spatial interaction between land uses, labour markets, land rents, and mobility (Verburg et al. 2004).

Sharifi (2016) details the major neighbourhood planning movements throughout the twentieth century being the Garden City as described previously, the Neighbourhood Unit that introduced walkable connectivity to institutions and services, Modernism with higher densities integrated with open space and public transport, Neo-Traditionalism and a return to the suburb as a secluded component of the urban environment, and finally Eco-urbanism which draws upon the concepts of urban metabolism and sustainability. Urban planning at the scale of the neighbourhood has been identified as critical to meeting the goals of sustainable development (Sharifi 2016) with the ability to apply climate resilient, resource efficient, and other sustainable approaches and design principles – such as in a recent trend of 'eco-urbanism' more easily applied in incremental changes at smaller scales as opposed to ambitious city-wide transformations.

The neighbourhood as a 'unit' of the city is therefore in a position to drive the transition to a CC. Loorbach et al. (2016 pp.28), describe the characteristics of the urban context with regard to sustainability transitions. These characteristics also apply to the circular neighbourhood as a concept and the broader goal of transforming the cities neighbourhoods into circular systems. The characteristics are geographic proximity (between actors), multi-scalar interaction (between different sized components), multi-domain interaction (convergence of different sectors), and personal and institutional proximity – neighbourhoods are environments were people live, work, and interact socially but also with formal institutions and cultural norms and habits. As described previously, for a city to be circular its functions must close material loops across various sectors; prioritize and generating new innovative industries and jobs; improve social and educational opportunities and co-locate circular land uses. The transition to a CE in the context of the neighbourhood therefore concerns its functions, its physical make-up, the behaviour of its inhabitants amongst each other and within the broader city, with the culmination of all actions decreasing its impacts upon the natural environment.

The United Nations and International Resource Panel's 'Weight of Cities' (IRP 2018) report identifies the resource requirements of future urbanisation and the future trends of the world's cities. Resource productivity in cities can be promoted through the spatial planning of the urban form to maximise efficiency. Compact urban growth integrated with efficient transport and land use is presented as a solution to previous urban forms dominated by detached single houses and urban sprawl, or super-blocks of large towers found in countries such as China. The form of the urban fabric directly reduces the resource and energy consumption required to support

neighbourhoods, with excessively sized buildings and infrastructures consuming far more than saved from their density. Mixed functionalities and social make-ups of neighbourhoods are also recognised as key to resource reductions in the urban environment.

Examples of circular neighbourhood projects implemented by Municipal Governments in combination with the private sector provide an insight into how the above interpretation applies to the practical manifestation of the concept. The circular neighbourhood project Buiksloterham is an example of a residential neighbourhood designed to as a "living lab for smart, circular development" (ARUP 2016 pp.56), through applying CE principles from inception to construction to operation and lifetime of the neighbourhood development (Metabolic 2014). The neighbourhood is located within the periphery of Amsterdam's centre and as a historically industrial precinct was devoid of heritage buildings and contained large empty plots. The project was initiated by the Amsterdam City Municipality to encourage innovative circular area development through the use of planning tools (top-down approach) circular land issue (public land release) and tendering of services (public procurement) by the Municipality (Williams 2020, pp.917). Beyond these initial spatial planning interventions, the development of the circular neighbourhood utilised a legislative 'free zone' approach, with the unknown elements of the CE and its implementation to be subject to analysis through the experimental approach.

The primary characteristics of the Buiksloterham neighbourhood were for it to be 'smart, circular, and biobased'. The CE was operationalised as 'regenerative and waste-free by design', but in addition to material reuse, biological material streams and bioprocessing were also introduced as elements of the circular neighbourhood. Social and human 'capital' was also a consideration of the development. The elements of the urban context being 'people, knowledge, data flows, and civic engagement' are the central focus of the neighbourhood's social shift towards a CE model. The linkages of the neighbourhood to the broader CC were established in a framework that spatially organises the relations of the CC – its centre and periphery, peri-urban areas and suburbs, the greater country and green spaces, further farmlands and nature, national and neighbouring countries, and internationally. The interventions for the circular development of Buiksloterham involved reducing the volume of local material flows, finding local supply synergies in energy and material, and supplying local material flows in a renewable fashion (Metabolic 2014).

2.4 Urban Metabolism and Circularity Indicators

The urban metabolism emerged as a concept for identifying energy consumption, waste production, and technical and socio-economic processes of urban environments (Wolman 1965). Embraced as a critical component for developing sustainable cities, it is characterised by the depiction of the inputs, outputs and storage of material flows (energy, water, nutrients and waste) within the city (Codoban and Kennedy 2008). The concept imagines the city as an 'organism' which metabolizes the materials it consumes and transforms them into buildings, human biomass, and waste (Decker et al. 2000) The material flow analysis (MFA) is a tool that has been developed to illustrate the urban metabolism, and has evolved from the 'mass balance accounting method' from the fields of Industrial Ecology and Engineering and expanded to incorporate material and

energy flows, socioeconomic and policy analysis into how the functions of the city are carried out with respect to resource consumption (Kennedy, Cuddihy, and Engel-Yan 2007).

The urban metabolism can be used to determine resource impacts, material stocks and material flows to examine and shape the role that location, urban form, technology and economics can play in the greenhouse gas inventories of our cities, with the aim of envisioning more sustainable communities and cities (Pincetl et al. 2012). The design and metabolism of urban spaces has been explored at the neighbourhood scale, with research analysing the way distinct neighbourhood forms with respect to energy efficient buildings and public transit have different implications for neighbourhood metabolisms (Codoban and Kennedy 2008). Pincetl et al. (2012) claim that the urban metabolism of the city has both "physical spatiality and longitudinal space" (history), and an expanded urban metabolism framework can bring the necessary holistic analysis required for a city to be circular. By linking lifecycle analysis to material flows, mapping flows spatially (to identify who, where and how materials are flowing throughout the city), integrating urban ecology and ecosystem services, and political ecology (how humans organize themselves to interact with nature), the closing of material loops and transition to a circular state can be mapped out and achieved.

Material flow analysis is a common tool for tracking a city's metabolism and is useful in aiding the transition to a circular city (Kennedy, Pincetl & Bunje 2011, Chrysoulakis et al. 2013). By quantifying and mapping the flows of energy and materials in the urban environment, the concept of the urban metabolism and associated technical analysis tools are being used as urban planning and urban design interventions for the circular city. The communication of the metabolism of the city to planners, architects and engineers as a decision support tool to compare urban planning outcomes across different scenarios based on their impacts upon material flows (Chrysoulakis et al. 2013) was found to favour green space development, and otherwise provided as a method to better inform decision makers of sustainability impacts of development projects. Conceptualising the city's 'metabolism' is vital to identifying material and waste flows and creating closed material 'loops' in urban regions to maximise circularity.

Whilst some European Municipalities have prepared circular strategies for their cities, a system to measure and evaluate progress towards circularity is identified as lacking, with existing framework indicators not applicable to the level of the city due to their wide scope – for example being relevant only to recycling or trading of waste or materials, but not energy and water (Paiho et al. 2020). Petit-Boix and Leipold (2018) identify that quantitative measures of circularity in Municipal CE strategies are largely based on life cycle analysis and material flow analysis. They are used as tools to estimate environmental impacts of material flows throughout their cities, but were mostly applied to spheres of industry and business, infrastructure (including waste and environmental management), and social consumption. Urban planning (identified as sustainable planning, land use and zoning) is identified as an overarching element of the city affecting its broader functions, but was generally not the focus of quantitative measures of circularity (Petit-Boix and Leipold 2018).

3. Theoretical Framework, Conceptual Framework & Operationalization

3.1 Theoretical Framework

The previous section details the concepts and theoretical perspectives of the CE as a solution to resource scarcity, the application of CE principles to urban environments and link to spatial planning within the city, and finally introduces the Circular Neighbourhood as a unit of the Circular City. As detailed within Section 4 of this thesis, the nature of this research is to develop an insight as to how the CC translates to the level of the neighbourhood, with an exploration of existing conceptualisations and theoretical background conducted to properly appropriate an existing research framework so that it could be adapted to the topic of the 'circular neighbourhood' and applied to a consistent document analysis process.

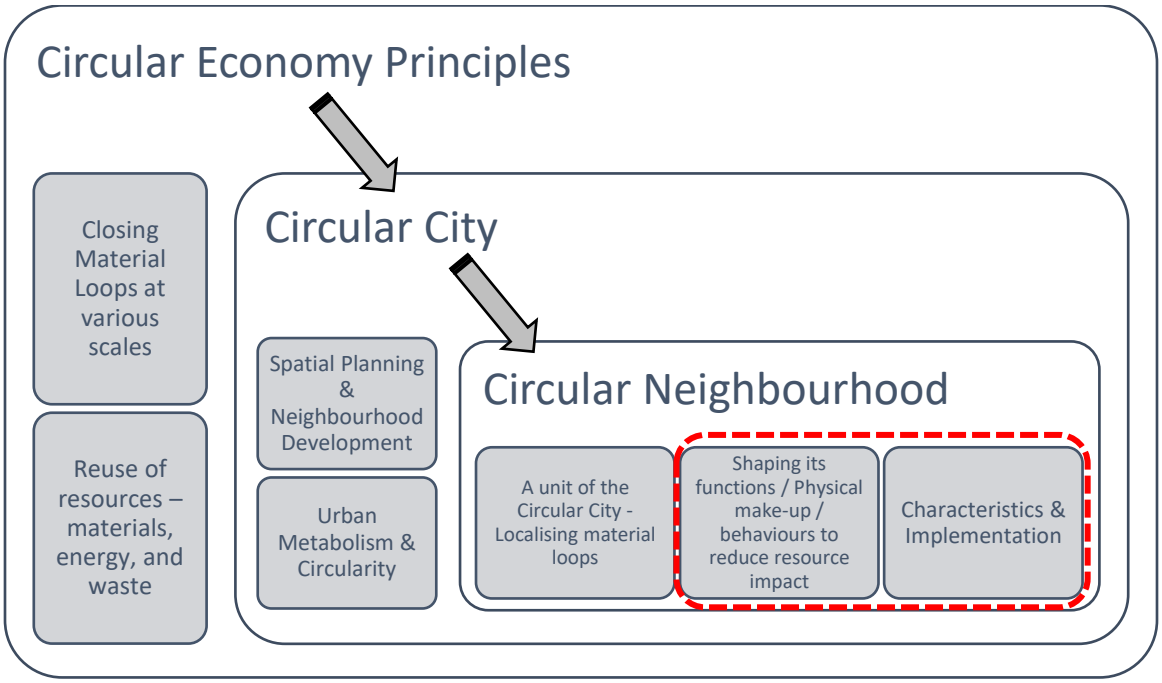


Figure 2 – Theoretical Framework

3.2 Conceptual Framework

The academic literature and existing conceptualisations at the intersection of spatial planning and circular cities present a gap at the concept of the circular neighbourhood, with only experimental neighbourhood development projects implemented as innovative manifestations of circular principles at this scale. The concept of the circular neighbourhood is not yet characterised in the academic literature, and as such the research framework of this thesis to explore the topic must be able to be applied to the concept and its variables.

As such, the conceptual framework provided by Pomponi and Moncaster (2017) at **Figure 1** providing 'six pillars' for the analysis of the circular economy was selected for this research. This structure considers the transdisciplinary factors of the CC as discussed previously. As the

transition to a CE involves economic, technological, societal, governmental, environmental, and behavioural elements; this thesis research on the CC interpreted at the level of the neighbourhood has utilised this existing framework (*Pomponi Framework*) and adapted it to address themes identified in the concepts and theoretical perspectives at Section 2. CE transitions at the scale of the neighbourhood concerns its functions, its physical make-up, the behaviour of its inhabitants amongst each other and within the broader city, with the culmination of all actions decreasing its impacts upon the natural environment

As such, the Pomponi Framework being relatively broad in its scope, whilst not relating specifically to cities, buildings, or products, acknowledges the varied and holistic nature of the CE as a principle. It allows for the specific topic to be framed within these dimensions. The framework was chosen for this research given the aims of the research relate to the neighbourhood scale which is characterised by the intersection of built environment, residents and their behaviour, its broader connection to the city, and urban processes at a local scale. Further, an analysis of the main components identified within the literature review and common amongst other research frameworks, it accommodates the broadest number of dimensions relevant to the scope of this research.

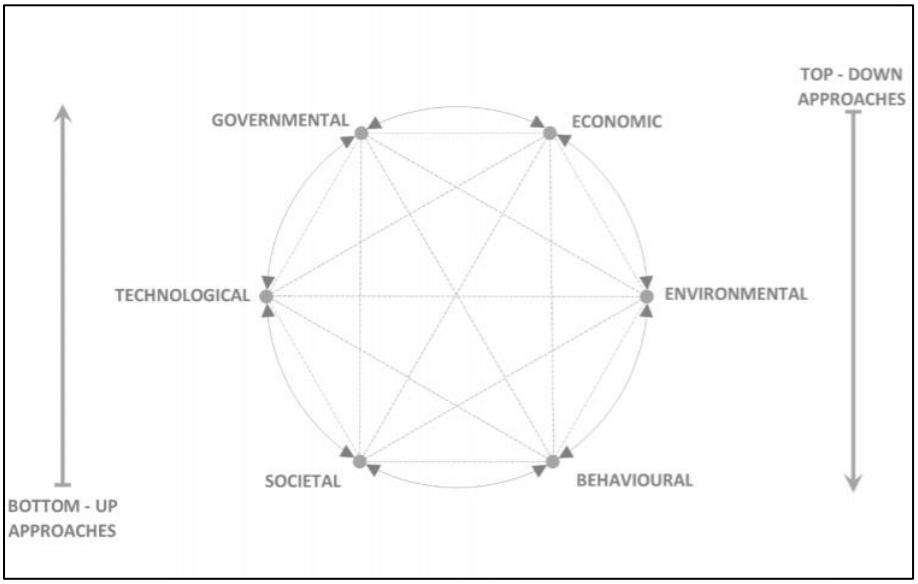


Figure 3 – Pomponi and Moncaster's six dimensions for building research in a circular economy (2017, pp.13)

Whilst it is acknowledged that existing criticisms of broader frameworks such as ReSOLVE are that they fail to relate to the entirety of the city's functions and characteristics, the Pomponi and Moncaster framework was adapted with this in mind. Due to the interpretive nature of this research including analysis of both top-down and bottom-up approaches to the CC at the neighbourhood scale, a more open-ended organisation of themes and characteristics was desirable. Pomponi and Moncaster (2017) identify a lack of research focused on construction and development in the CE, but exploration of the topic has subsequently grown both in research and practice. Their pillars have been repurposed to apply to the level of the neighbourhood. The subject of this research involves the various factors established by the framework and as such was used to formulate the analysis criteria for each case.

The *Pomponi Framework* is adapted to be applied to the circular neighbourhood based on the concepts revealed throughout the literature review. As detailed in Section 3.5, the concepts were operationalised based on the structure of the literature review which analysed existing knowledge of the CE and CC as it has historically developed, to the scale of the city, followed by its link to spatial planning and neighbourhood development, and measurement and indicators for circularity.

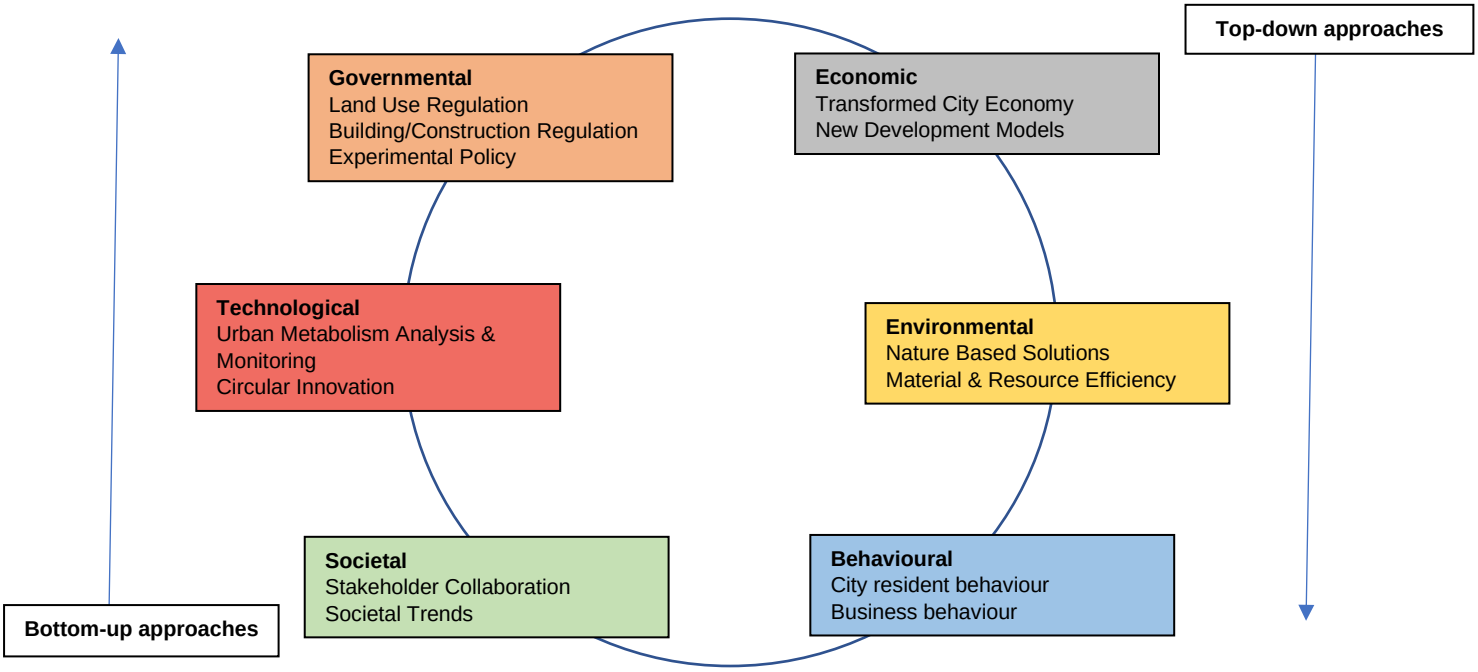


Figure 4 – Pomponi and Moncaster Framework adapted for this research (Source: Author)

3.3 Operationalization of Concepts

The operationalisation of the Pomponi and Moncaster (2017) framework in the neighbourhood within the circular city involves first defining the key concepts of the circular economy, circular city, and neighbourhood. Following from this, each dimension of the framework is categorised by variables and operational definitions. This follows from the steps provided by Van Thiel for research design (2014) and allows for the framing of the analysis within the context of established characterisations of the CC within existing literature. This formed the basis for the document analysis for each city strategy and provided for consistent terms of reference when researching the interpretation of strategies to the neighbourhood.

3.5.1 Circular economy, Circular city, and Neighbourhood

The concepts of the circular economy, circular city and neighbourhood are categorised in the below table based on the literature review at Section 2.

Table 1 – Concept Definitions

Concept	Definition
Circular economy	Management of resources – materials, energy, and waste aimed at reconciling economic and environmental prosperity. Reshaping both production processes and consumption trends across economic sectors, human behaviours, and environments.
Circular City	Incorporation of the principles of the circular economy across a city environment. Encapsulates the physical, spatial, and human elements of the city and its processes (built environment, infrastructure, natural environment, economic processes, social processes, governance). The circular city's functions must close material loops across various sectors; prioritize and generate new innovative industries and jobs; improve social and educational opportunities and co-locate circular land uses.
Neighbourhood	For the purpose of this research the neighbourhood is considered as a spatial unit of the city made up of residential land uses with ancillary other uses (Lancaster 1966) that interacts with and is linked to other neighbourhoods, the city as a whole, and a broader region (Hartman et al. 2011, Verburg et al. 2004). The characteristics are geographic proximity (between actors), multi-scalar interaction (between different sized components), multi-domain interaction (convergence of different sectors), and personal and institutional proximity. Neighbourhoods are environments were people live, work, and interact socially but also with formal institutions and cultural

Concept	Definition
	norms and habits (Loorbach et al. 2016 pp.28). The CE transition in the context of the neighbourhood concerns its functions (interactions), its physical make-up (built environment), the behaviour of its inhabitants amongst each other and within the broader city. The culmination of all actions therefore decreasing its impacts upon the natural environment.

3.5.2 Dimensions of the Circular Neighbourhood

The dimensions of the circular neighbourhood are detailed to allow for their operationalization in research. The framework provided by Pomponi and Moncaster (2017) seeks to balance the interconnectivity, linkages, and interdependency of urban systems with a social approach of 'balancing' stakeholders, enterprises, and communities within local development.

The table below details instances of each dimension within the context of the CC, divided into variables and operational definitions. The operationalization of each dimension is linked directly to the research question *"How is the circular city interpreted at the scale of the neighbourhood?"* by providing concise framing for each aspect of the circular city and how it relates to the neighbourhood as a unit of the city.

The variables have been formed based on the outcomes of the literature review in Section 2, with key themes identified based on examples from the existing academic research. The 'fit' of different themes across various dimensions reflects the interconnectivity of the categories of the circular neighbourhood. The variables provided are purposely broad, with the below table to be expanded and confirmed based on the analysis of each Circular City strategy, consistent with the Grounded Theory research philosophy which will allow for the 'circular neighbourhood' to be developed throughout the document analysis and expert interviews.

Table 2 – Dimensions of the Circular Neighbourhood

Dimension	Variables	Operational Definitions	Key Themes
Governmental	Land Use Regulation	Spatial Planning	*Zoning to encourage mixed functionalities and social make-ups for resource reduction* *Co-locating land uses to support*

Dimension	Variables	Operational Definitions	Key Themes
			circularity long-term through synergies *Industrial symbiosis by reintroducing remanufacturing and repair*
		Circular Development Incentives/Requirements	*Conditions for development consent that require circularity*
	Building Regulations	Construction materials	*Reuse of recycled or waste construction materials*
		Performance Standards	*Urban refurbishment of energy inefficient buildings* *Efficiency standards – insulation, heating, water reuse*
	Experimental Policy	Living Labs & Free zones	*Stakeholder collaboration across public/private sectors in Circular Projects, involving novel 'deregulated' approaches*
Economic	Transforming the City Economy	Diverse Urban Economies	*Recycling, repair, remanufacturing businesses*
		Share Economy & Platform Economy	*Products-as-a-service reducing ownership and take/dispose models* *Mobility-as-a-service platforms*

Dimension	Variables	Operational Definitions	Key Themes
			Not for profit trade/share platforms for circular activities
	New Development Models	Public-Private Partnership Land Development	*Circular Development through a living lab approach* *Active land use policy – holistic approach to development & planning for circular principles* *Passive land use – setting up the rules for circular development*
Environmental	Nature Based Solutions	Application of ecological systems for circularity - resource reuse/waste minimisation	*Regulating services (Trees reducing heat island effect, natural water retention through landscaping)* *Provision services (Community gardens, food forests)*
	Material & resource efficiency	Reusable materials used for construction of new buildings	*Construction waste use*
		Repurposing of waste materials for development	*Retention and life-cycle extension of waste materials from demolition*
Behavioural	City resident behaviour	Consumption Trends	*Acceptance & attitudes towards circular activities/business models*
		Reduce waste produced	*Engaging in waste reduction behaviour*

Dimension	Variables	Operational Definitions	Key Themes
		Reuse & recycling of household goods	*Closing material loops in the home through recycling, gardening, etc.*
	Business behaviour	Circular production processes	*Remanufacturing & production from waste*
Societal	Stakeholder Collaboration	Citizen and community group projects	*Non-profit share economy platforms for recycling/reuse* *Bottom-up circular initiatives*
	Societal Interactions/Trends	Sustainable mobility (Active transport, sustainable public/private transport)	*Bike/Pedestrian infrastructure* *Sustainable public transit* *Electric vehicle infrastructure*
Technological	Circular Innovation	Products and services based on CE principles	*Building material passports* *Innovative applications of waste material*
	Urban Metabolism	Data monitoring and quantifying material flows throughout urban processes	*Urban mining (monitoring of valuable materials in existing built environment and tracking for reuse)*
		Integration of technology into the built environment for circularity	*Technological monitoring of natural systems to improve their management*

Table 2 above identifies shared elements of the themes identified in the literature review across the CE, CC, Spatial/Urban Planning and the Neighbourhood, and in turn operationalizes common concepts which are used in the document analysis. Where gaps are provided, the following sections aim to provide a better picture of the circular neighbourhood through the document analysis.

4. Methodology

4.1 Research Strategy

This research was carried out through collecting relevant city strategy documents and related literature relevant to the topic of the circular neighbourhood. The literature and strategy documents form the basis of the research, which is then corroborated by expert interviews to triangulate the analysis and help to answer the research questions.

The purpose of the research question is to interpret the policies and strategies of cities seeking to engage in a sustainability transition to the circular city, and as such is categorised as interpretive research or hermeneutic inquiry as it will "help uncover meaning, develop understanding and discover insights relevant to the research problem" (Merriam, in Bowen 2009). Grounded theory research as a form of qualitative investigation relies on collecting data and analysing it in a logically consistent procedure, filtering data through an interpretive lens, and developing theory as a result of the analysis (Charmaz 1996). It is an inductive approach to research which involves identifying patterns and discovering theoretical properties in the data that is analysed (Bowen 2009).

As such, the nature of this research to develop an insight as to how the CC translates to the level of the neighbourhood will examine and interpret various CC strategies through a consistent analysis of relevant texts. This is carried out through the use of an existing research framework adapted to the circular neighbourhood as identified through the concepts discovered during the literature review. In combination with the literature review this document analysis will inform expert interview questions which will then supplement the desk research as a form of triangulation.

Grounded theory approaches generally delay the literature review within the research as they are inductive, and the researcher "follows the leads gained from [their] view of the data, not from the careful and exhaustive literature review" (Charmaz 1996). Notwithstanding, in this thesis, a thorough literature review was conducted to properly appropriate an existing research framework so that it could be adapted to the topic of the 'circular neighbourhood' and applied to a consistent document analysis process. Given the innovative and far-reaching characteristics of the CE, it was considered that a thorough examination of the topic history, existing conceptualisations, and trends in literature were required to carry out a complete interpretive analysis of the units of research.

4.2 Methodological Approach

This research was undertaken using desk research, looking at a variety of circular city strategies and associated circular neighbourhood development projects across Europe to answer the research question. This research involves document analysis and expert interviews with the purpose of the research being aimed at contributing to a growing body of knowledge on the CE transition of cities. As detailed within the literature review at Section 2, a research gap is identified in the focus on the neighbourhood within the circular city and so this approach is considered suitable to understand and explore the topic, followed by analysis and discussion.

The research conducted as part of this thesis is interpretive, looking to identify and analyse documents to answer the research question. Yin (2014) identifies case studies as being suitable for exploring a certain topic by studying how it is carried out in a specific example. This approach will be utilised to gain a deeper understanding of the CC as a concept through the analysis of CC strategy/vision documents prepared by Municipal Governments to shape their circular transition. It will also explore how the concept is expressed in these documents and planned to be implemented at the level of the neighbourhood. Desk research is carried out to collect and analyse the case documents and to identify key concepts relating to the visions for the circular city and how they relate to the neighbourhood. The data is analysed in accordance with the adaptation of the analytical framework of Pomponi and Moncaster (2017) discussed previously and the operationalisation detailed in Section 5, which is broad enough to encompass the varied elements of the 'circular neighbourhood'.

Case study research was chosen as it can be applied to qualitative research through an interpretivist perspective (Harrison et al. 2017) and is relevant to this research seeking to explore the circular neighbourhood as a concept as it is expressed across multiple cities and contexts. As the concept of the CE has been shaped and implemented at various levels of business and government, the circular city and its implementation has followed. Several research frameworks, monitoring tools, and strategies have been formed to assist the transition to the CC, but nevertheless there is a need for an exploration for how existing 'top-down' strategies and visions affect neighbourhood development. Further, the recent trend of government and private developer-led circular area development projects are an example of 'bottom-up' implementation of the concept, and so an exploration and analysis of experts' knowledge in how these practical examples interpret circularity is suited to case study research. The analysis of both how circular strategies will shape the neighbourhood and feedback from experts in the field of circular neighbourhood projects reveals commonalities or differences that are useful in forming a deeper insight into the research question.

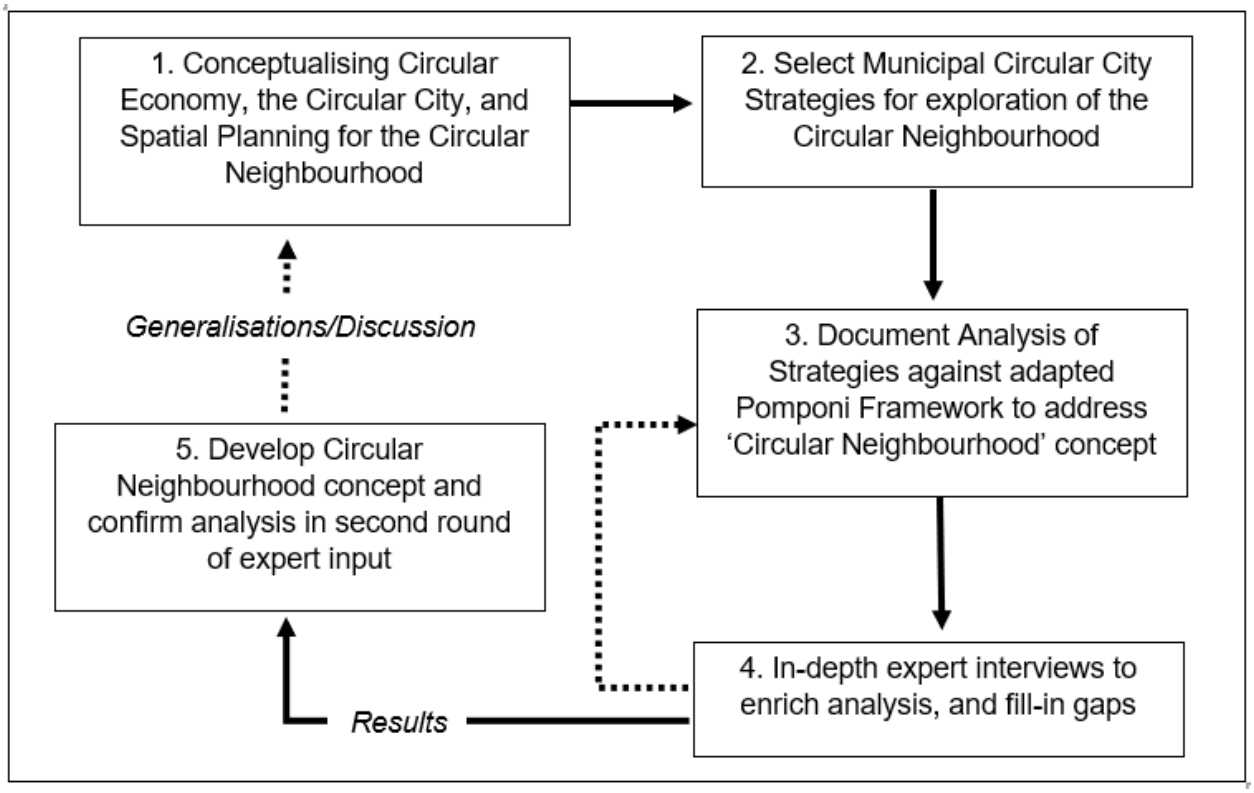


Figure 5 – Methodological steps of research – interpretive approach

4.3 Methods

4.3.1 Document Analysis

Document analysis is the primary research method of this thesis, in combination with expert interviews. Bowen (2009, pp.33) describes the use of document analysis as the process of "evaluating documents in such a way that empirical knowledge is produced and understanding is developed" and is carried out in combination with other qualitative research methods as a means of triangulation, which allows for convergence and corroboration of data and findings across different methods. The method itself can also serve as the sole source of data for interpretive research or hermeneutic inquiry. Documents will be analysed through a systematic criteria analysis of each strategy for its fit against the research framework detailed in Section 5. The 'interview' technique as described by O'Leary (2014) will be used to 'ask questions' of each strategy through skimming, reading and interpreting to then provide answers that respond to each dimension of the operational framework. The data gathered from this analysis was subsequently tabulated.

This analysis served to create an initial "broad, overall picture" of each document (Bowen 2009) and allowed the meaning of each document to be uncovered with respect to CC transition at the scale of the neighbourhood. Then, an illustration of the characteristics of a 'circular

neighbourhood' categorised emerging themes revealed in each document. Bowen (2009) identifies the potential concerns with maintaining objectivity when carrying out document analysis and cautions for the need of a robust and systematic approach to improve the credibility and validity of the research. In this research, the two eight-step planning processes for document analysis described by O'Leary (2014) are utilised to ensure a structured approach. The first steps are to create a list of texts and consider how they will be accessed, acknowledge biases, develop appropriate skills and consider strategies for credibility, and know the data that is being sought out. The second stage is to gather the texts, develop an organisation scheme, assess authenticity, explore the agenda and biases of each document, explore background information, and finally ask questions and explore content.

4.3.2 Interviews for triangulation

A combination of document analysis and expert interviews can serve as distinct methods that can complement each other in an interactive way (Goldstein and Reiboldt 2004). Information revealed from the document analysis was used to formulate the questions asked during the expert interviews phase of the research. The analysis of different city strategy documents and conclusions drawn from them is used to form questions in a Delphi method of expert interview following the 'estimate-talk-estimate' format described by Rowe & Wright (1999). Interviews were chosen as a method to complement the data gathered from document analysis. Interview subjects were selected based on their expertise and experience in implementing CC projects as part of a private consultancy engaged by Municipal Governments to prepare strategy documents. Interviews in qualitative research can be carried out in an interactional manner, with the data gained from the participant being considered 'data-as-topic' (Rapley 2011). The interviews did not follow a strict question and answer format to extract information but rather were carried out to build a conversation and construct 'data' to enhance and potentially corroborate the conclusions and analysis gained from the document analysis portion of the research.

4.3.3 Delphi Method

The Delphi method was utilised as a methodological foundation to carry out interviews with research subjects, noting participants were selected based on their expertise with respect to the implementation of circular transition projects at the city scale. This method was well-suited to answer the research question as it is flexible, effective, and efficient for developing an understanding of topics where there is an 'incomplete knowledge about a phenomenon' (Skumolski, Hartman & Krahn 2007). As identified within the literature review in Section 2, the circular neighbourhood has been explored in practice in bottom-up projects and is still a subject of growing research with little explored as to how CC strategies will shape neighbourhood development of the future.

The Delphi method is characterised by the anonymity of the expert participants, an iterative process where participants refine their views, controlled feedback, and aggregation of responses (Rowe & Wright 1999). It is flexible in that iteration can be carried out across multiple rounds or only once, with this flexibility being particularly useful for this research noting that the contact with participants was limited. Iteration was carried out by first providing participants with preliminary conclusions from the document analysis as a launch point for the interview conversations. This

was followed by gathering feedback from an expert after their review of the research results and discussion section, including an aggregation of the interview data.

4.3.4 Literature Review

A literature review approach was used comprehensively as part of this thesis research. Initially used to complete the literature background of the thesis and formulate the research question, it was also used to locate policy documents, city strategies, and reports related to the topic area. It allowed for the identification of government documents, non-profit organisation contributions, the work of global independent bodies, and private enterprise contributions to the topic of research. The primary units of analysis are policy and strategic documents from relevant authorities including at the EU, National, and Municipal/City levels; as well as interviews with experts related to pilot circular neighbourhood projects and area developments, seeking to capture a both 'top-down' and 'bottom-up' examples and interpretations of the circular city at the neighbourhood level to answer the research question.

The method has been used extensively in CE and built environment research (Benachio, Freitas & Tavares 2020, Merli, Preziosi & Acampora 2018, Foster & Kreinin, 2018), to describe and explore recent developments and trends in the field noting the need for establishing common definitions, concepts, and understandings of the topic. Similar to the methodology of Foster and Kreinin (2018) who used the method to form environmental impact indicators for the adaptive reuse of cultural heritage buildings with respect to the CE, the document search process of this research was iterative and involved the identification of documents using reference search engines Google Scholar and Radboud University's RUQuest. Key words were searched as well as combinations of relevant terms including 'circular city', 'circular economy', 'circular neighbourhood', 'strategic planning', 'vision making'. Policy and strategic documents were identified through the literature research, existing private research bodies including the Ellen Macarthur Foundation, and also through European Commission project documents (European Commission 2020, European Commission 2019).

4.4 Document Analysis approach

In accordance with the process for creating a structured research approach discussed earlier (O'Leary 2014), the following sections detail the steps taken to select documents and organise the data collection.

4.4.1 Selection of texts & Access

The proposed city strategy documents were chosen based on the preliminary literature review carried out as part of initial research into the topic of the CC. European cities were selected based on the frequency of their reference in background academic literature, with documents such as EU's Climate KIC Circular City Project (Climate-KIC & C40 Cities 2018) assisting in identifying relevant texts. A city within the United Kingdom – London was also included regardless of their exit as part of the EU, noting it forms part of the European continent, and this strategy reflected EU examples of other cities' ambitions towards a CC. A non-European city – New York was also selected to provide a comparative example of a CC strategy outside of the cultural context of the other strategies (Europe) and to provide a 'control' unit of data.

Strategy documents were selected based on their completeness and quality of information with respect to the breadth of topics covered. Most strategies that were selected involved a narrative vision, objectives, action plan, and relevant examples of the envisioned outcomes, which was sought after given its relevance to the research question. Whilst more CC strategy documents were discovered during the literature review, where their scope included only economic aspects, it was considered that the absence of neighbourhood and planning specific data suggested incompatibility with the research aim. Finally, preference was given to texts that were accessible based on recency and ease of access online, with all documents accessed through the internet.

4.4.2 Biases & Research Skills

Researcher bias is to be minimised through the triangulation of data collected from document analysis in combination with expert interviews to help establish credibility of the results. Further, a structured approach to the data collection provides a clear step-by-step method by which data was collected. Whilst document analysis is the subjective interpretation of data contained in the units of research, the transparency of the process of analysis provides a 'map' of the research carried out to improve credibility and validity.

Document analysis and other research skills were refined throughout the preliminary stages of this thesis and research proposal stage, and throughout the completion of coursework related to the Masters thesis prior to undertaking the research.

4.4.3 Data being sought out & Organisation scheme

As detailed in Section 3, the data being sought from each document was categorised based on the adapted research framework (Pomponi Framework). The multi-dimensional structure of the framework has been altered to respond to the 'circular neighbourhood' characteristics identified through the literature review. Documents were skimmed for relevant extracts based on their fit against the research framework, guided by the operationalisation and variables built from Section 2. Other pertinent extracts from the documents that did not correlate directly to any variables but related to a dimension were selected and highlighted intuitively where relevant.

Extracts collected from the documents was categorised in accordance with the dimensions of the research framework and tabulated (**Annexure 2**), with annotations provided for the pages from each document. These annotations were removed when analysing the document 'responses' in Atlas.ti software.

4.4.4 Authenticity, Agenda & Background

The authenticity and agenda of each city strategy document is discussed in the introductory segments of each strategy in Section 5 below. The background of the document, its objectives, and how it applies to the future urban development of each city is detailed prior to the analysis.

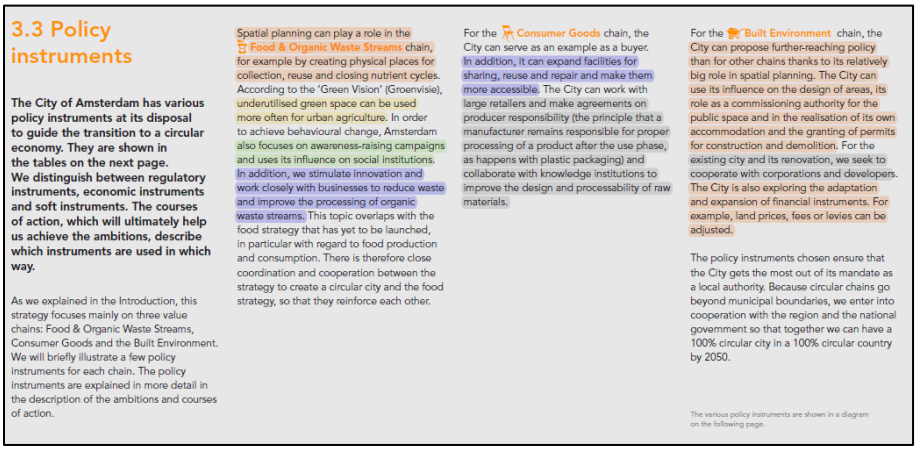
4.4.5 Analysis Structure & Coding

The final steps of the O'Leary (2014) document analysis procedure being to ask questions of the documents and explore content were then carried out. The following details the steps taken:

1. Each document was skimmed, and relevant data (text) highlighted and colour coded based on its fit to the dimensions of the research framework (**Annexure 1**). This was carried out as an initial step to extract fragments from the data which corresponded to the

'questions' asked for each dimension (Example at **Figure 6** below). It allowed for specific fragments of the documents related to the circular neighbourhood topic to be extracted and annotated with their page number, avoiding the input of entire documents into the Atlas.ti coding software.

- This step was utilised as the strategy documents were all structured differently. Introductions, narratives, vision statements, global examples, and action plans were detailed throughout most strategies, whilst some contained material flow analyses and pilot project recommendations for each city. The initial extracting of fragments from each strategy allowed a first-pass review and focus on specific elements of the strategies which would shape city and neighbourhood development. This step was critical to ensure the data was focused towards answering the research questions.



3.3 Policy instruments

The City of Amsterdam has various policy instruments at its disposal to guide the transition to a circular economy. They are shown in the tables on the next page. We distinguish between regulatory instruments, economic instruments and soft instruments. The courses of action, which will ultimately help us achieve the ambitions, describe which instruments are used in which way.

As we explained in the Introduction, this strategy focuses mainly on three value chains: Food & Organic Waste Streams, Consumer Goods and the Built Environment. We will briefly illustrate a few policy instruments for each chain. The policy instruments are explained in more detail in the description of the ambitions and courses of action.

Spatial planning can play a role in the Food & Organic Waste Streams chain, for example by creating physical places for collection, reuse and closing nutrient cycles. According to the 'Green Vision' (Groenvisie), underutilised green space can be used more often for urban agriculture. In order to achieve behavioural change, Amsterdam also focuses on awareness-raising campaigns and uses its influence on social institutions. In addition, we stimulate innovation and work closely with businesses to reduce waste and improve the processing of organic waste streams. This topic overlaps with the food strategy that has yet to be launched, in particular with regard to food production and consumption. There is therefore close coordination and cooperation between the strategy to create a circular city and the food strategy, so that they reinforce each other.

For the Consumer Goods chain, the City can serve as an example as a buyer. In addition, it can expand facilities for sharing, reuse and repair and make them more accessible. The City can work with large retailers and make agreements on producer responsibility (the principle that a manufacturer remains responsible for proper processing of a product after the use phase, as happens with plastic packaging) and collaborate with knowledge institutions to improve the design and processability of raw materials.

For the Built Environment chain, the City can propose further-reaching policy than for other chains thanks to its relatively big role in spatial planning. The City can use its influence on the design of areas, its role as a commissioning authority for the public space and in the realisation of its own accommodation and the granting of permits for construction and demolition. For the existing city and its renovation, we seek to cooperate with corporations and developers. The City is also exploring the adaptation and expansion of financial instruments. For example, land prices, fees or levies can be adjusted.

The policy instruments chosen ensure that the City gets the most out of its mandate as a local authority. Because circular chains go beyond municipal boundaries, we enter into cooperation with the region and the national government so that together we can have a 100% circular city in a 100% circular country by 2050.

The various policy instruments are shown in a diagram on the following page.

Figure 6 - Example of deductive coding approach: Extracts from Documents

2. Then, each highlighted extract was read in context and 'questioned', to provide coherency amongst fragmented extracts (**Annexure 2**). The extracts were organised against the questions under each dimension. This provided for an 'interview transcript' against each strategy that provided answers to how the strategy would be interpreted to the neighbourhood scale being the focus of this research.

3. Finally, the data – 'interview' of each document was uploaded into Atlas.ti software and coded (**Annexure 3**). Themes were formed against both the existing operationalisation and variables (deductive approach), as well as unidentified themes given new codes for analysis (inductive approach). The codebook was detailed under the Memo function of the software.

The colour coded documents, tabulated extracts from each strategy, and Atlas.ti data set are contained at **Annexures 1-3** of this thesis, with the final results from the data discussed in Section 7.

Table 3 below links the dimensions of the circular neighbourhood (from the adapted Pomponi Framework) and the questions asked of each document. Bowen (2009 pp.38) states that "the

analysis of documents [is] instrumental in refining ideas, identifying conceptual boundaries, and pinpointing the fit and relevance of categories".

In this regard, the below structure reflects the adapted Pomponi Framework to identify conceptual fit and categories, allowing for relevant data fragments to be extracted from the city strategy documents rather than analysing them directly in Atlas.ti. This provided a more focused analysis of the strategies' interplay with the circular neighbourhood concept by first extracting fragments against the established operationalisation and variables in a deductive approach. This was then followed by a deeper questioning of the data during coding and analysis using the software, to present finer details and reveal new themes in an inductive approach.

Relevant fragments of the documents were selected against the analysis structure based on their relation to each question, being a form of deductive coding corresponding to themes generated from the research operationalisation (Van Thiel 2014, pp145). The fragments were then copied into Atlas.ti for more detailed analysis, including formation of themes against the variables, construction of unidentified themes, and development of sub-themes which provided sensitivity towards findings that did not match the initial operationalisation of the framework in terms of variables and definitions. Objectivity is aimed for by representing each document in accordance with the same framework and sensitivity to the data, providing responses where there are no direct answers to the questions but rather subtle cues to meaning in each document (Bowen 2009).

Table 3 – Analysis structure applied to documents

Circular Neighbourhood Dimension	**Variables**	**'Question' for Documents**
Governmental	Land Use Regulation Building Regulations Experimental Policy	1. How are spatial planning tools going to be shaped by this CC strategy? 2. Are there incentives to encourage circular development in the future? 3. What will neighbourhood buildings made of and how will they function under this strategy? 4. Is there planned collaboration for circular development projects between government and the public?
Economic	Transforming the City Economy New Development Models	1. What diverse urban economies are promoted? 2. Are new economic models envisioned within the neighbourhood?

Circular Neighbourhood Dimension	Variables	'Question' for Documents
		3. Does the strategy consider new land development models with respect to financing circular development?
Environmental	Nature Based Solutions Material & Resource Efficiency	1. How does the strategy relate to the natural environment in the neighbourhood – vegetation, natural features of the land? 2. What is the vision for circularity in materials and resources used in neighbourhoods?
Behavioural	City Resident Behaviour Business Behaviour	1. Are any resident behaviour shaping tools promoted within the strategy with respect to consumption, reuse and recycling trends? 2. How do businesses behave under the vision and planned actions of this strategy?
Societal	Stakeholder Collaboration Societal Interactions/Trends	1. Does the strategy seek stakeholder collaboration for circular projects within neighbourhoods? 2. What broader societal trends will form part of the CC?
Technological	Circular Innovation Urban Metabolism	1. Is CE innovation of products and services involved in the strategy? 2. How is the urban metabolism monitored within the city/neighbourhood? 3. What technology is envisioned to be part of urban environments in the CC?

4.4.5 Results

The use of Atlas.ti software to code the document extracts allowed for the categorisation of themes identified against the existing operationalisation framework, as well as new concepts and data that had not been considered. The production of codes and sub-codes in the program, and creation of 'memos' allowed for analysis of each city strategy including instances of co-occurrences of themes, dominant themes, and outliers which had not previously been mapped within the operationalisation and research framework.

Code-code networks were created within the software to visually represent how concepts and themes related to each other and provided a theoretical understanding of the data, with examples of networks contained at **Figures 6 & 7** below. In the first instance, the following results section contains a summary of findings grouped under each dimension of the Pomponi Framework. Outliers and instances of co-occurrences are identified which demonstrate the strength of certain concepts amongst the analysis.

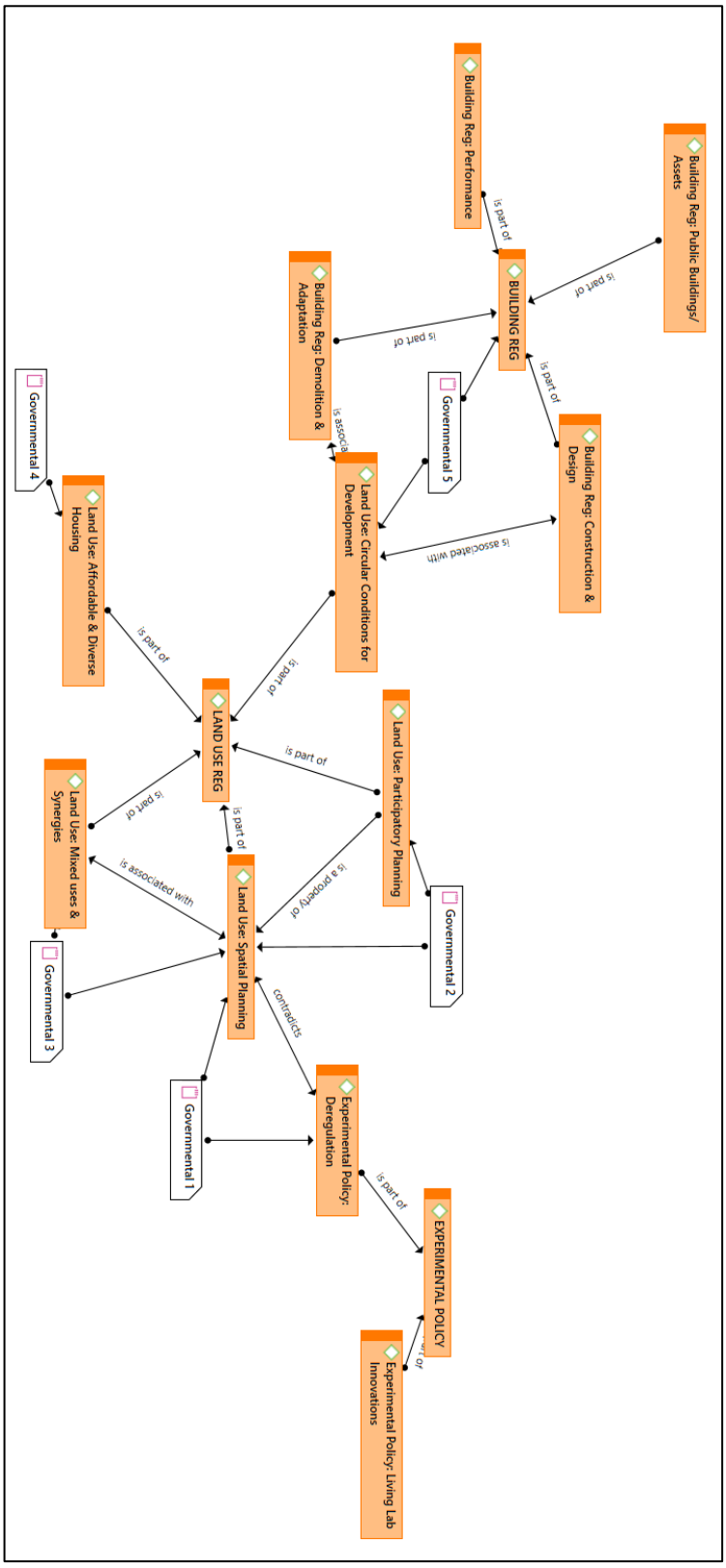


Figure 7 – Atlas.ti code-code network with 'memos' for the Governmental Research Dimension

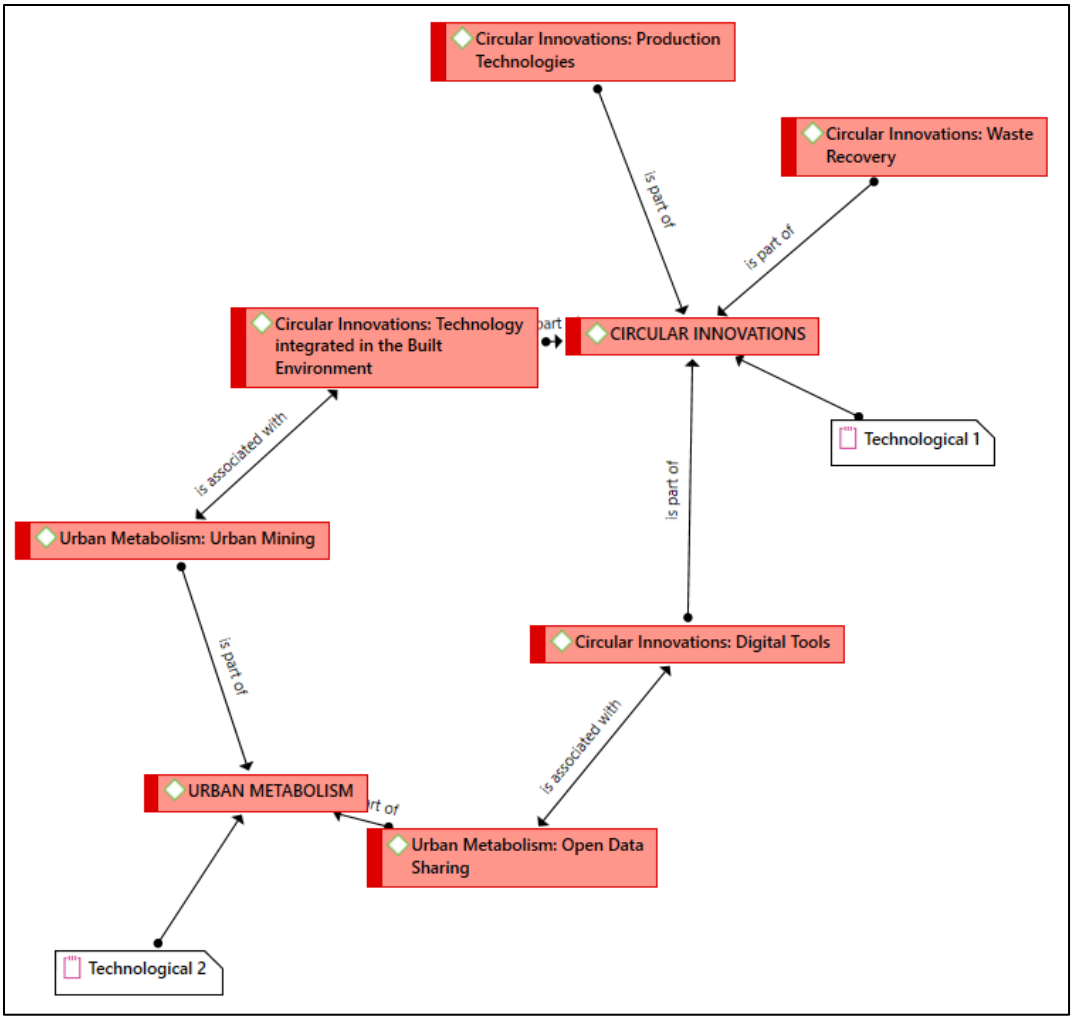


Figure 8 - Atlas.ti code-code network with 'memos' for the Technological Research Dimension

Further, the network feature of Atlas.ti was used to answer the research questions by linking relevant variables for each question across dimensions, and providing results of the analysis with reference to each sub-question.

5. Circular City Strategy Analysis

The analysis of each CC strategy document has been carried out based on the application of the operationalisation of the research framework to answer the research questions. This section of the thesis details the approach to selecting the relevant city strategy documents, followed by the structure of the analysis and how it was used to answer the research questions, and finally the written analysis of each strategy.

5.1 Data Analysis

The following section contains the analysis of each CC strategy. The background of each document, its objectives, and how it applies to the future urban development of each city is described in the introduction section. Then, the authenticity and agenda of each city strategy document is discussed, namely who has prepared the document and who it is aimed towards.

5.1.1 Amsterdam Circular 2020-2025 Strategy (Gemeente Amsterdam)

The Amsterdam Circular 2020-2025 Strategy was developed by the Municipality of Amsterdam to provide an actionable plan for the city to reach its ambitions of becoming a circular city by 2050 and halving its use of new raw materials by 2030. The strategy details planned actions of the Municipality in collaboration with other stakeholders that are going to be undertaken to become a CC. The strategy is divided into an introduction into the CE and its purpose as a solution to the city's current development, a vision for the CE in Amsterdam, a plan of action for the city, and finally progress monitoring and indicators.

Framed within a 'donut model' depicting the city's use of raw materials within the Earth's planetary resource boundaries, the strategy aims to transform the city into a CC to reduce raw material use and energy consumption. The CE is presented as the solution to the problem of unsustainable resource use within the city. Climate neutrality, ending waste, extracting and preserving value from products and materials, and developing economic opportunities from a CE are all aims of the strategy.

The ambitions and actions of the strategy have been categorised across three value chains to provide a cross-sectoral approach to the implementation of the CE in the city. These include food & organic waste streams, consumer goods, and the built environment.

5.1.2 London's Circular Economy Route Map (London Waste and Recycling Board)

This strategy is presented as a route map containing the steps towards the London Waste and Recycling Board's (LWARB) vision for London as a circular city. The document identifies the economic benefits of a CE, focusing specifically on the net benefit of seven billion pounds a year by 2036 if the city implements the actions contained in the strategy. Aiming to contribute to London's aspiration to become a zero carbon city by 2050, the document identifies the need to shape the conditions for which a CE can flourish, with a specific sectoral approach across material and waste streams in the built environment, food, textiles, electronics, and plastics.

The city's population and urban growth are identified as key issues that are to be addressed by a CE implementation across the city, with the vision to create a "more flexible and sustainable approach to products, housing, office space and critical infrastructure crucial to London's ability to adapt and grow" (LWARB 2017 pp.7). The LWARB provides their vision, identifies challenges,

provides examples of bottom-up projects in the city, and finally action and policy options for each sector that have been developed with city stakeholders. The document is a collaborative call to action inviting organisations, businesses, and other stakeholders in London to engage with and support the vision. The recommendations of the strategy will go on to inform the Greater London Authority's broader planning strategies such as the London Environment Strategy.

5.1.3 Rotterdam Circularity Programme 2019-2023 (City of Rotterdam – Rotterdam Circulair)

Rotterdam's circularity programme was developed following research commissioned by the city in the report 'Circular Rotterdam: Opportunities for new jobs in a zero waste economy' (Metabolic et al. 2018) which determined the four key sectors for a circular Rotterdam across construction, consumer goods, agri-food and 'green flows', and healthcare as these were identified as the key areas whereby the most value of material flows and the largest impacts could be made in a transition to a CE. Further, opportunities for job creation and CE employment were a focus of the research.

Following from this report, the City of Rotterdam formed its circularity programme to lay out the current CE initiatives being undertaken in the city, and a path towards a complete CC in the year 2050. Goals for halving the city's use of fossil raw materials, increasing jobs that contribute to the CE to 7,000 and 'close material cycles' by the year 2050. The ambitions of the strategy revolve around the region's role as a manufacturing and logistical hub, and the knowledge and labour background of the city.

5.1.4 Paris Circular Economy Plan (City of Paris)

The Paris Circular Economy is a governance strategy and action plan to meet the city's previous ambitions for a transformation towards the CE. The launch of the Greater Paris Assembly on the Circular Economy and associated white paper dividing 65 CE proposals across seven strategies were the initial steps prior to the implementation of the Paris Circular Economy Plan. The action plan prioritises and establishes the initial actions to be undertaken based on the numerous proposals contained within the white paper.

5.1.5 Complex challenges. Circular solutions: Jobs and opportunities for New York City in the circular economy (New York Circular City Initiative & Freshfields Bruckhaus Deringer)

This strategy was formed on behalf of the New York Circular City initiative and convened by the law firm Freshfields Bruckhaus Deringer. It is a research document applying CE principles to New York in a vision to create 'the first truly circular urban economy'. Whilst the strategy focuses on a transition to the CE through economic changes to existing economies in the city, the multi-sectoral approach of the vision has provided for different levers to impact a transition. Further the strategy positions a transition to the CC as a way to address economic recovery and inequality exposed as a result of the COVID-19 pandemic.

The strategy presents actions based on their impact on jobs, economic growth and the environment. The use of a non-European strategy provides a comparative document and the completeness of the text with respect to its approach is useful for the analysis. The actions and vision contained within the strategy can be interpreted down to the level of the neighbourhood within the city, and given the higher density of residential neighbourhoods within New York, and its position as the second largest city in terms of consumption (New York Circular City Initiative 2019 pp12), provides a suitable contrast to the European units of analysis.

5.1.6 Circular Cities Switzerland: Basel (Circle Economy, Ecos, & Municipality of Basel-Stadt)

The 'Circular Cities Switzerland' project is a collaboration between the Municipalities of Basel-Stadt and Bern in Switzerland with the research non-profit Circle Economy and Ecos. The project involved the creation of strategic visions for both cities as 'lighthouse projects' to demonstrate the economic feasibility, social advantages and environmental benefits of a transition to the CC. The strategies are comprehensive and involve agenda setting and contextual framing based on the characteristics of each city, followed by a material flow analysis of various sectors of each city, then strategies providing practical and scalable circular actions based on priority material streams, and finally elaboration of clearly defined lighthouse projects' developed through consultation with stakeholders who could lead the circular project.

The sections of the strategies subject of the document analysis where Phase 3 *Circular Strategies* and Phase 4 *Action Plan* of each strategy. These sections contained the developed visions for circular actions within each city. Further, the 'challenges and directions for further exploration' section of Phase 2 *Material Flow Analysis* was analysed as these sections contained vision-based solutions to the material flow streams which served to shape the visions established in later phases.

The three priority areas for the city of Basel determined based on the material flow analysis were the construction, real estate & tourism, and household sectors. The priority areas and subsequent strategy and action plan for the city were suitable for the research based on their completeness and strong relationship between the circular neighbourhood and plans for the priority areas.

5.1.7 Circular Cities Switzerland: Bern (Circle Economy, Ecos, & Municipality of Bern)

As detailed above, the 'Circular Cities Switzerland' Bern strategy was structured in the same way as the previous document as they were prepared as one project. The three priority areas determined for the city of Bern were waste management, municipal real estate, and food. The priority areas and subsequent strategy and action plan for Bern were suitable for the research based on their completeness. Whilst the priority area – food of this strategy had a weaker link with the circular neighbourhood concept the evaluation contained in Phase 2 *Material Flow Analysis* including visions and directions shaped the strategy and provided additional data to answer the questions for each dimension.

6. Expert Interviews

Interviews were carried out with experts to triangulate the data obtained from the document analysis by either corroborating findings or identifying gaps in the analysis. The interviews were carried out in an interactional manner, with the data gained from the participant being considered 'data-as-topic' (Rapley 2011). The interviews produced a conversation that covered the topics identified and interview questions following the interview guide at **Appendix 1**.

Experts were selected based on their experience as a researcher or consultant in the field of CE application within urban environments, with each expert providing a different perspective based on their specialisations which served to enrich specific topics under the Pomponi Framework. Two participants were interviewed separately, and then follow-up discussions were held seeking additional feedback after the data received from 'Round 1' interviews was aggregated and analysed.

Table 4 – Expert Interview Structure

Expert	Date	Expertise	Organisation
#1	13/4/21	Circular City Strategy Consultant, Originator of the 'Internet of Nature' (Smart Urban Ecology), PhD	PhD & Post-Doctorate Research Previously Metabolic (Consultancy)
#2	18/4/21	Circular Economy Consultant, Data Scientist – Urban Environments	Metabolic (Consultancy)

6.1 Coding Interviews

Interviews were transcribed using transcription software 'Otter.ai' which provided for written transcription of recorded audio. The transcription produced by the software was reviewed while following the audio recording and any errors were corrected. Further, the written conversation was formatted to better identify the speaker, intonation, and pauses in speech, as well as removing irrelevant adverbs and . 'Otter.ai' also provided a frequency indicator of topics discussed throughout the transcription. Interviews were coded using Atlas.ti software alongside the city strategy documents, providing a consistent application of the analysis across both the documents and interview data.

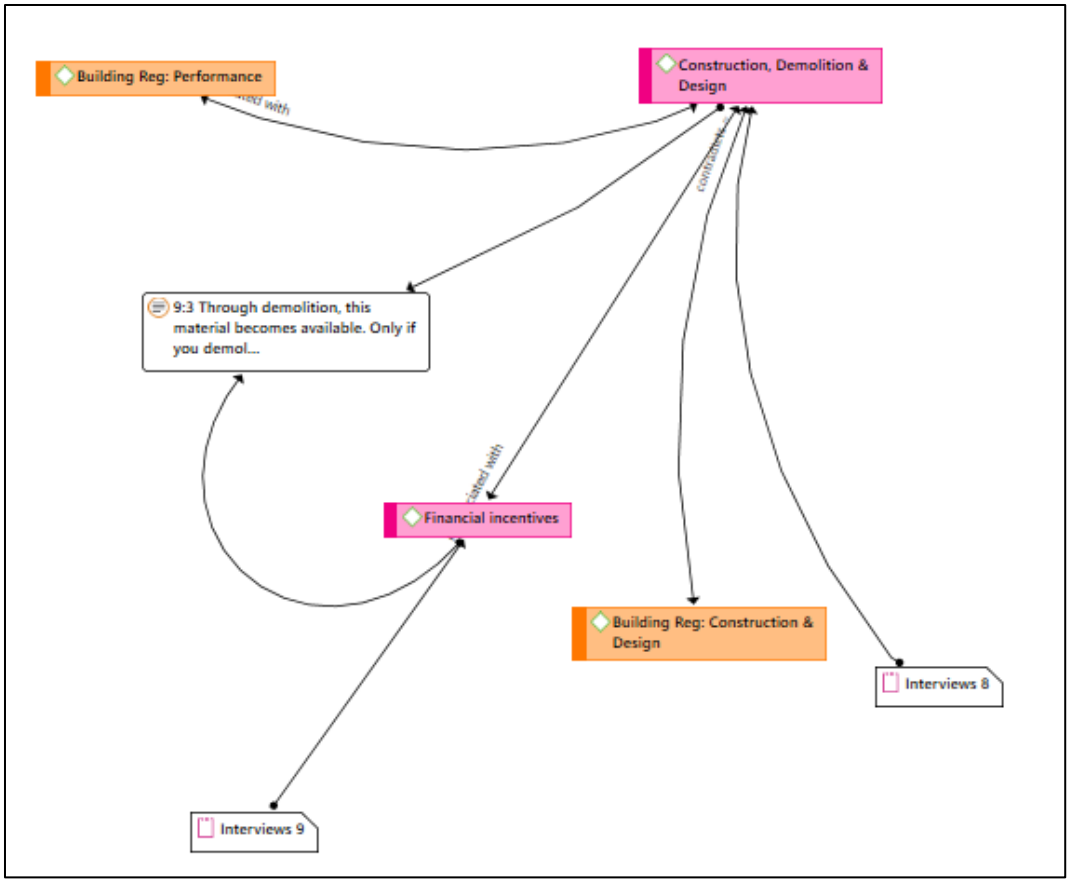


Figure 9 - Atlas.ti network for interview codes "Financial Incentives" & "Construction, Demolition & Design"

6.2 Interview Data

The analysis of the interview data is detailed within Section 7 under the dimensions of the Pomponi framework. The interview data was coded alongside the city strategy documents to provide a consistent approach to the analysis and allowing for a structured approach when detailing the results of the research against each dimension of the research framework. The networking feature of Atlas.ti software allowed for visualisation of links between the interview data and the document analysis, with connections and contradictions amongst themes and specific quotes able to be presented as depicted in **Figure 8** above. 'Memos' were created to describe the networks formed which allowed for the relevant data extracted from the interviews to be detailed under each dimension of the research framework in Section 7 below.

7. Results

The following section details the result of the document analysis being a hybrid deductive approach extracting relevant data from each strategy, and inductive approach of coding the extracts within Atlas.ti software. The results section is structured to allow for an integrated interpretation of the data across all cities against the conceptual framework.

The use of code-code networks within the software allowed for representation of the data with reference to each dimension of the Pomponi Framework. Document co-occurrence tables allowed for the identification of dominant thematic content, concepts that were previously unidentified within the operationalisation and literature review, and outliers or new concepts/themes identified during the analysis. The results of the expert interviews have been detailed under each dimension with data received during interviews including critiques of certain concepts or contributions that provide additional insight beyond the findings extracted from the documents.

The following details the results in accordance with each dimension, any new themes discovered, interesting relationships amongst themes, and other findings from the research.

7.1 Governmental

The Governmental dimension of the research provided meaningful insight into the role of spatial planning and top-down interventions in the transition to a Circular City model. Generally, a focus on prioritising space for circular activities such as recycling and repair was identified, with future spatial planning concerned with the colocation of land uses based on the ability for materials to be circulated as much as possible.

The analysis suggests a greater focus on planning for market transformation towards a CE and creating synergies amongst activities as opposed to the physical design of the built environment. The use of space for food production and the subsequent need to consider urban agriculture in future planning was also a core theme of most strategies. Higher densities within urban environments and a variety of different land uses within close proximity to each other in an effort to localise material and waste loops suggests a diversification of previous planning trends with respect to neighbourhoods within the city. New economic models such as the platform economy rely on planned higher densities for sharing and social links amongst residents within the city.

Further, the role of Municipal governments as catalysts for the transition to a CC was clear – ambitions for circular public tendering and procurement policies, CE principles embedded into planning processes and regulation, and the use of deregulation as a tool to encourage innovation in small-scale projects was a strong theme across the strategies. Whilst building regulations and enforced use of secondary materials was predicted within the operationalisation, a distinction was identified between broader strategic planning for collocating land uses, and more site specific criteria – with building criteria also to be shaped by collaboration between government and built environment professionals.

Experimental Policy & Deregulation

Bern's city strategy contained the most instances of experimental policy or deregulation of planning legislation to promote circular activities (**Figure 10 below**). Whilst all strategies referred

to this form of stimulating circularity, this concept generally contradicts the overall vision for the role of spatial planning in the CC, focusing on organising activities, land uses, or otherwise controlling development towards circularity. It was identified that deregulation is to serve as a form of encouraging small-scale innovative development approaches in the city. These 'living labs' could present novel circular solutions to resource cycling whilst also acting as both a 'test run' and catalyst for change to top-down planning processes. A significant focus was placed on learning from, and 'scaling up' successful experiments that work in solving a resource problem, as well as sharing experiences and knowledge of these approaches across stakeholders to stimulate and inspire larger development.

	Experim... 9	Experim... 29	**Totals**
1: Amsterdam Strategy Responses 145	1	2	3
2: Basel Strategy Responses 106	2	4	6
3: Bern Strategy Responses 90	3	9	12
4: London Strategy Responses 120		4	4
5: New York Strategy Responses 116	2	2	4
6: Paris Strategy Responses 84	1	5	6
7: Rotterdam Strategy Responses 67		3	3
Totals	9	29	38

Figure 10 - Experimental Policy Deregulation / Living Labs Document Co-occurence Table

Participatory Planning & Community Driven Circular Development

All strategies except for London included examples of community driven approaches to planning processes, land development, or vision making. Inclusion of community driven circular projects, developing innovative solutions through neighbourhood collaboration and participative democracy models was an unexpected concept revealed in the analysis. In addition to the Economic dimension variable "*Financing Circular Development*" these community driven planning approaches included the funding of neighbourhood development through co-creation or crowd funding as a means to distribute financial stakes and produce long-term relationships amongst communities, developers, and government.

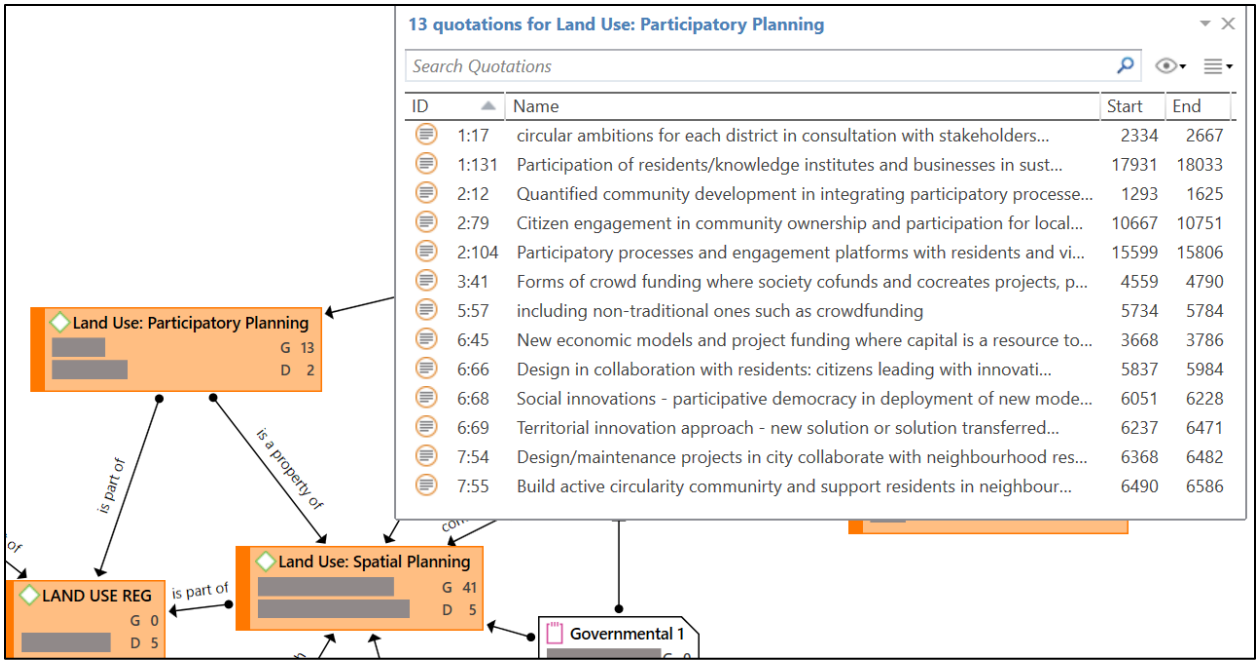


Figure 11 - Participatory Planning as an unexpected theme

Spatial planning & Mixed Use synergies

A clear distinction was made between spatial planning, and planning for strategic placement of land uses in the city to maximise synergies amongst different uses. Spatial Planning approaches including strategic plans were identified as ways of shaping visions for the city to include planning for urban food production in development projects, economic development through planning for CE activities, and integrating circularity into planning processes.

Alternatively, land use planning aspect of aligning mixed uses to maximise closing resource loops was largely aimed at shaping the future zoning of land to co-locate space that could be used for connected land uses. Beyond industrial symbioses between businesses and production, it included combining residential land uses with food production or commercial uses, and mixing functions within neighbourhoods to include diverse economies. This allows for closing the distance between households which produced recyclable materials and their conversion into new products. This localised planning also extends to connecting flows of buildings with respect to heat, water, and waste use to minimise emissions and long-term environmental impacts of building performance.

The expert interviews also provided insight into considerations for design of neighbourhoods in the Circular City (**Figure 12** below). The ideas presented generally involved the reduction of infrastructure dedicated to parking and private transportation, with residential land uses being well-integrated with public open space and green space within the city. Whilst the strategies placed a strong emphasis on cities containing urban agriculture, remanufacturing and repair businesses, and closed loops in resources and materials, the interviews provide a different description. Specifically, small scale community gardens that service residents and local

businesses, diverse economies and small-scale repair/recycling businesses, and decentralised renewable energy infrastructure across buildings was communicated by the experts.

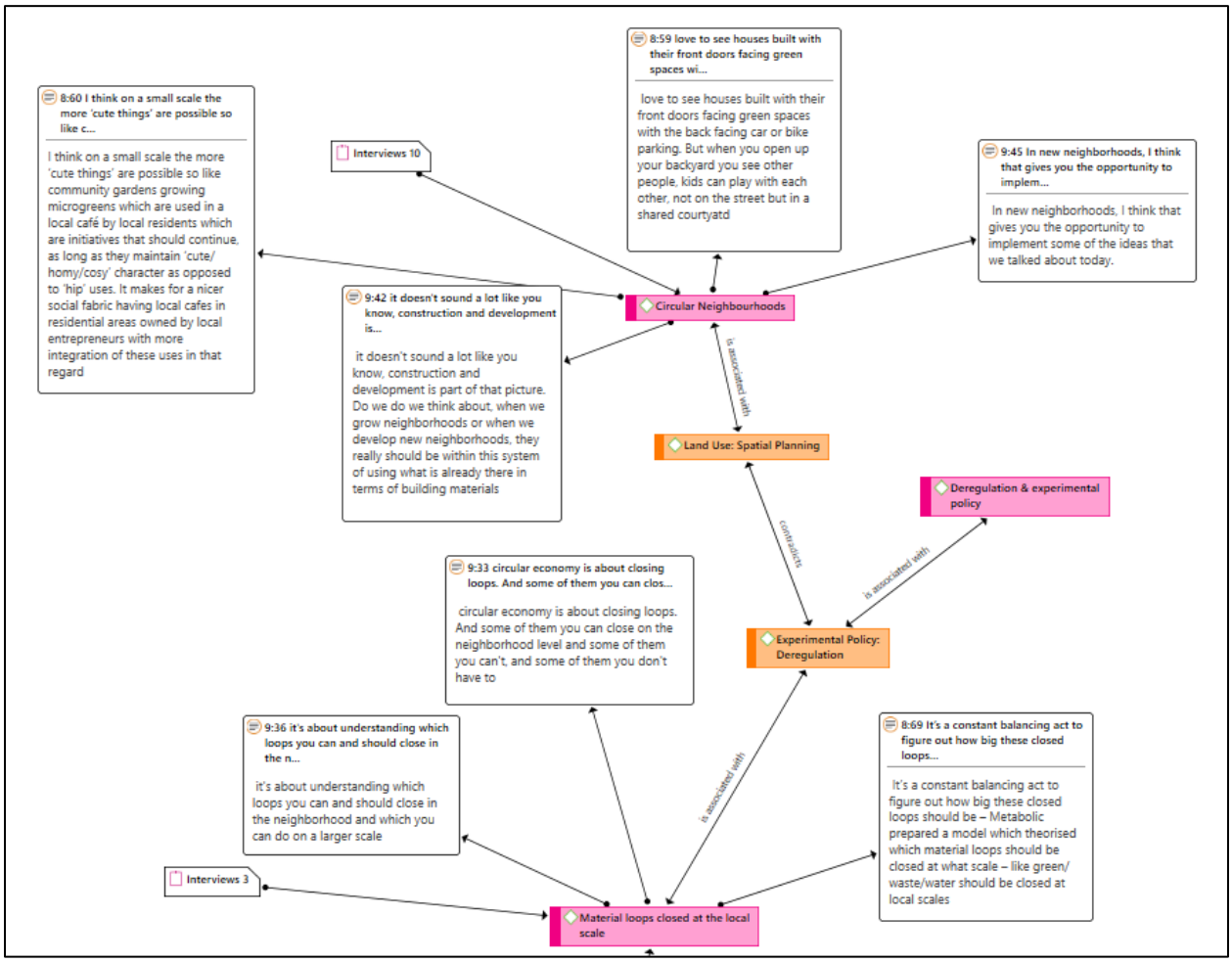


Figure 12 - Interview Code-Quote Network for Circular Neighbourhood Design

Housing Affordability

The Amsterdam, London, New York, and Paris strategies envisioned affordable housing as part of the circular city (and neighbourhood), noting Amsterdam was the outlier with six code occurrences compared to only one occurrence for the other cities. Existing issues with housing affordability in the cities were aimed to be solved by meeting housing demand through circular design including adaptive and modular construction to create new homes catering to changing needs of city residents. Further, circular development is planned to address housing affordability in its design to foster community support and strengthen links between land development and residents. London's strategy provided an example of a modular social housing village located within a long-term redevelopment site, that would be relocated locally as required. This was an example of the concept of 'meanwhile' spaces that were unique to London's strategy. The dedication of space that is under development and currently unused to serve living lab experiments had not been previously identified in the thesis operationalisation. These 'meanwhile'

spaces would include local food production, small scale diverse economy activities, and in the case of 'LADYWELL' the construction of a modular social housing project containing 24 homes that is capable of being moved once its location is redeveloped (London Waste & Recycling Board 2017, p.16).

Further, mixed uses and the increased occupancy of buildings to maximise resource use was presented as a solution to high commercial rent by increasing the use of buildings across multiple actors. Collaborative circular development projects were identified as being able to encourage affordable projects due to their inclusion of stakeholders across society, for example building collectives. Developing preconditions for circular development was envisioned for shaping the financial system for land use - social housing, private real estate, and city owned land is all to be shaped with a focus on circularity through government regulation.

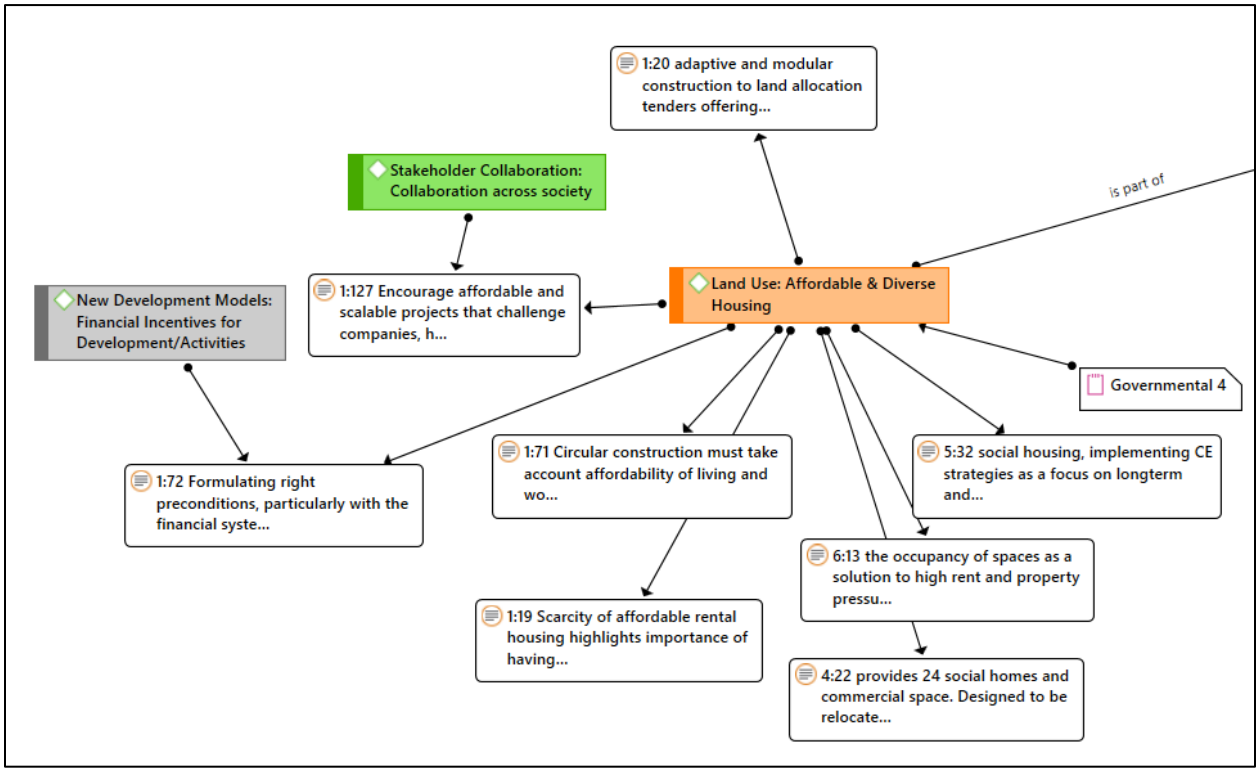


Figure 13 – Code-Quote Network for Affordable Housing theme, also depicting code co-occurrences with other dimensions

Land Use Regulation & Building Regulation

The analysis revealed a distinction between circular conditions for development and building regulations. Whilst the themes overlapped in terms of their affect of land development in the city, it was clear that circular conditions for development focused more on the application of procurement and tender guidelines to existing planning processes related to public owned land. Building regulations provided distinct matters to be considered by building permit processes including their impact on the design, demolition, and construction of buildings, and their lifetime performance geared towards closing resource loops.

Interview #1 identified the potential 'gap' between implementing circular building regulations and the practicality of working with secondary and recycled building materials. This expert raised their experience in speaking with a tradesperson involved with the construction of a circular neighbourhood 'living lab' project they had been involved in. The expert suggested that significant restrictions on using industry-standard building materials due to the lack of financially comparable alternatives was a barrier to proper implementation of building regulations based on circular principles. The safety and impact upon workflow due to this type of restriction on material use was identified as an issue.

Further, whilst the strategies focused heavily on recovery of materials from demolition sites, Interview #2 raised the difficulty in retrieving valuable and usable materials from demolished buildings, with the importance of change across the entire development supply chain and supporting it with material hubs and associated logistics initiatives being critical in linking policy with practice in circular construction. The transformation and adaptation of buildings rather than complete demolition was considered a more 'circular' way of developing the city as this allowed for "80% of the materials [to be kept] as most of it is in the structure and foundation of a building" (Expert Interview 2).

It was acknowledged that the use of highly resource intensive materials such as steel was less important in circular construction with regard to localising material loops. These materials were acceptable when recycled at a National or Trans-National level due to the inefficiencies in their production and manufacturing. From a resource perspective, Expert #2 provided that it was "still economically and environmentally sound" for recycled steel to be transported over long distance for reuse in construction.

7.2 Economic

The analysis revealed a strong focus on diverse urban economies, sharing platforms and Product-as-a-service economic models within the city. Repair and recycling services, and larger scale remanufacturing services are key to orientating the city's economy towards closing loops between second-hand and broken products, and new products.

New Markets & 'Reshoring' in the City

Themes related to transforming the city economy were the second most occurring across all documents and were generally represented evenly across the different strategies. All strategies envisioned a large role for product-as-a-service models, the sharing economy, and repair & upcycling services within the city. The importance of these models was emphasises with respect to reducing consumption at the resident level, changing business trends, and more broadly allowing for maximising the value of materials before reaching their end of life and then reintroducing them to circulation through remanufacture.

Secondary material platforms as a new form of market to allow for trade of secondary materials was a significant part of each strategy, particularly with respect to building sites and land development. Further, alternative currencies, including digital currencies were mentioned across three strategies as a way of encouraging behaviour amongst residents. The incentivization and even 'gamification' of consumption to improve recycling and participation in the diverse economy, was seen as a way to shape consumer decisions towards sustainable choices. This would also involve connecting networks of businesses and public services with consumers to catalyse a shift in behaviour.

		1: Amsterda... 145	2: Basel Strat... 106	3: Bern Strat... 90	4: London St... 120	5: New York... 116	6: Paris Strat... 84	7: Rotterda... 67	Totals
Transforming the City Economy: Alternative Currencies	6		4	1	1				6
Transforming the City Economy: Products-as-a-Service	26	3	4	5	5	7	1	1	26
Transforming the City Economy: Repair & Upcycling Services	35	6	2	9	3	8	3	4	35
Transforming the City Economy: Reshoring	9				3	3	2	1	9
Transforming the City Economy: Secondary Material Platforms	12	3	4		1	3	1		12
Transforming the City Economy: Sharing Economy	26	7	5	1	1	2	10		26
Totals		19	19	16	14	23	17	6	114

Figure 14 - Code-document co-occurence table for 'Transforming the City Economy'

Finally, a trend for 'reshoring' of economic activities was identified as a new theme contained within the London, New York, Paris and Rotterdam strategies. As a way to improve resilience of cities against current supply chain and resource shortage issues, cities identified the need to reintroduce manufacturing, material recovery, and other activities to urban areas that are currently carried out overseas. Designing the circular city to incorporate recycling activities and reindustrialisation was key to circularity with respect to products and consumption, as well as reducing the associated environmental impacts of current import and export trends in cities.

The sharing economy and repair/upcycling services within the neighbourhood were identified within both expert interviews and reflected the prevalence of these concepts within the document analysis. The spatial implications of co-locating these land uses within neighbourhoods was identified, with the potential to reduce the use of space for transport and logistics which impacts

upon the amenity and function of residential areas. Further, the increase of repair and upcycling services within cities was linked to shaping consumption habits of residents and reducing spending on new products, potentially improving overall satisfaction and connection to community amongst city residents.

Land Development Models

New land development models were most common in the Amsterdam and Bern strategies, and generally these included the co-funding of circular projects through collaboration of different sectors. Scalable projects are to be formed between companies, housing corporations and educational institutions to test innovative building projects and neighbourhood experiments. Additionally, crowd funding or circular funds created by communities, combined with the use of tendering and renumeration agreements with start-up businesses were examples of the implementation of circular land development.

The provision of assets such as land, buildings or even a neighbourhood for the implementation of living lab approaches was also explored. Financing development through increased tax revenue from circular activities, and including the risks involved with resource scarcity and climate change as factors when financing land development were new methods of steering current development models towards circularity. Alternatively, the expanded valuation of existing buildings and new financial and policy instruments would steer development towards retention of building materials in the built environment.

Financial instruments to shape traditional land development towards achieving circularity were identified across the Amsterdam, Basel, Bern, and London strategies. As depicted in **Figure 15** below these included utilising land value capture from the sale of land to reward desirable developments or curb undesirable ones, or reducing Value Added Tax for the retrofitting and adaptation of existing buildings to align with the construction of new buildings to encourage retention of buildings in development. Fees and taxes on the use of virgin construction materials, sending materials to landfill, or to encourage recycling services were also identified. Subsidising rents and reducing taxes on diverse economy land uses would also shape the future economy of the circular city.

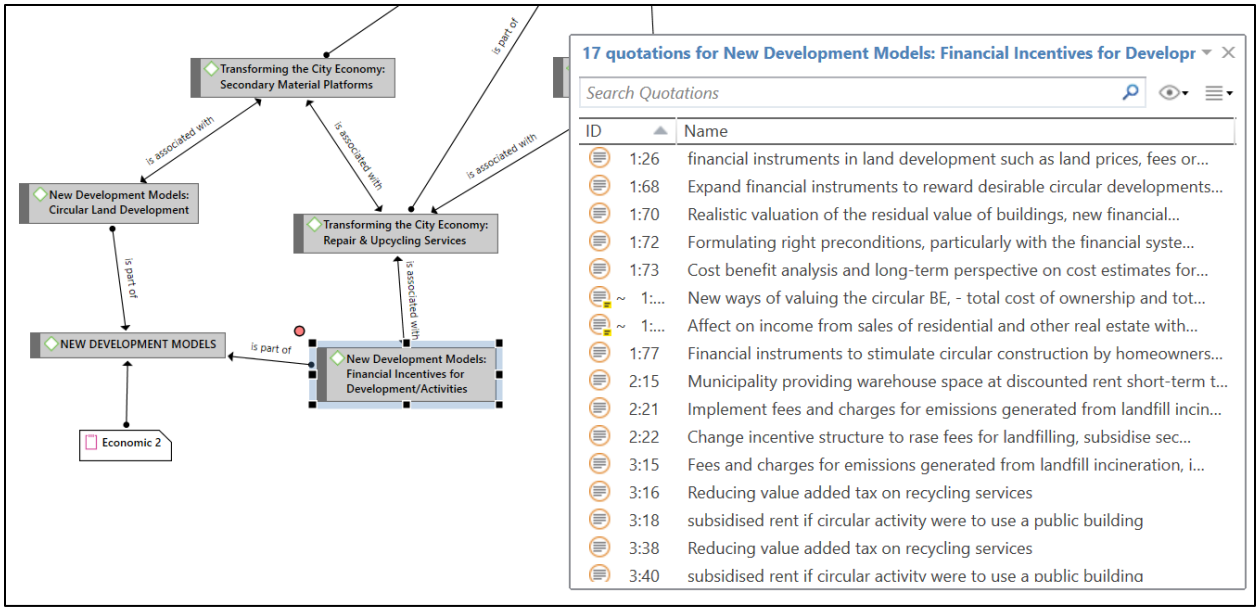


Figure 15 - Quote occurrences for 'Financial Incentives'

Expert Interview #1 confirmed the need for new financial models and considerations when funding and valuing land development as depicted in **Figure 16** below. Specifically, the need to finance development with respect to upkeep and maintenance over a longer period of time, noting building performance involves the environmental impacts of a building's use throughout its life. A model was presented that would allow for builders to recover the potential higher costs of developing land under circular regulations by capturing savings from the resource efficiency of the building throughout its first years of life, for example with respect to energy costs. This was discussed as a way to incentivise circular construction without financial instruments such as taxing, but a model such as this would directly contradict the envisioned benefits of circular renovation contained within some of the strategies - that lower income households would see financial benefit from reduced energy costs (Gemeente Amsterdam 2020 p.78). Interview #1 also identified a key barrier to implementing circularity through renovation of private housing stock, being the financial incentives and cost burdens associated with retrofitting rental housing for energy efficiency. While this is a key component of each strategy, current private rental housing is not encouraged to implement circularity due to the cost-profit relationship between building maintenance and rental income for private landowners

Finally, the use of public funding was identified in Interview #2 as critical in supporting business cases for land development that might not be financially feasible under current development models. Government initiatives to finance circular development models, technological innovations, or up-scaling of projects would accelerate the 'transition phase' of the CC and allow for cities to meet Government ambitions for circularity where otherwise market forces would not support them.

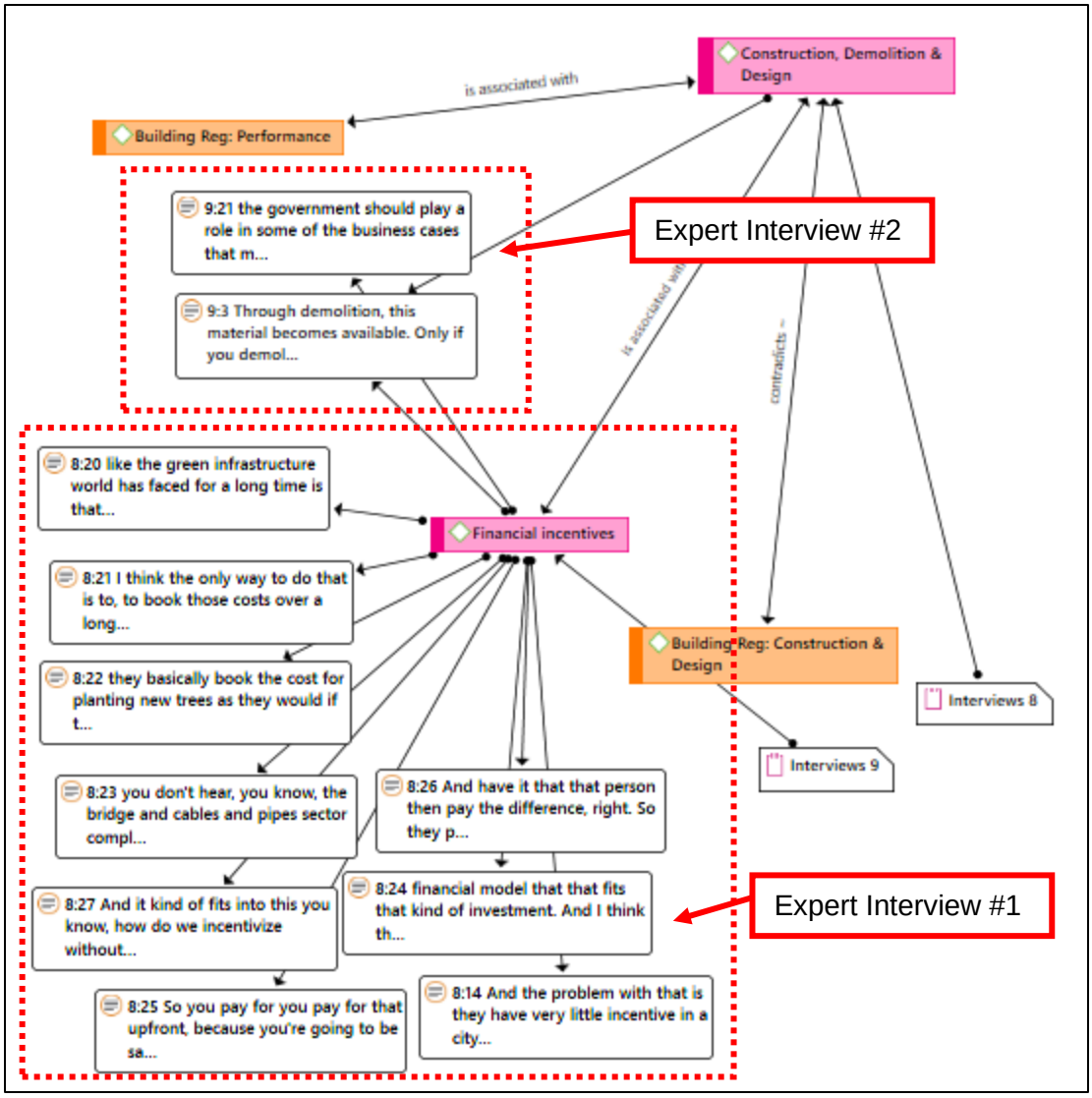


Figure 16 - Interview Code-Quote Network for 'Financial Incentives for Circular Development' depicting quote extracts from each interview

7.3 Environmental

Urban agriculture and local food production within the city was a key component of most strategies. Urban farms within existing green spaces within the city, as well as integrated into the built environment were presented as a critical component of reducing environmental impact with respect to logistics (transporting current food sources) and waste (current food waste trends). The integration of nature-based solutions into the environment was not as prominent, but it was recognised that future development will integrate reuse of water and heat between buildings.

Nature in the Circular City & Resource Efficiency

Nature based solutions as an element of the CC were rarely envisioned within the strategy documents, with few references to nature-based infrastructure to enhance local biodiversity and regenerate natural systems in cities. Six occurrences of references to the 'ecodesign' of green spaces and efforts to return nature to neighbourhoods including the reduction in current private transport infrastructure.

A criticism of the lack of natural design in implementing strategies was identified within the expert interviews as depicted in **Figure 17**. Whilst designing cities based on material flows and land use synergies was a focus of strategic transition plans, the consideration of the city's natural and social ecosystem was criticized as not being strong enough in Expert #1's experience as a consultant in the field. This was considered to be a reflection of the document analysis which presented little instances of natural design envisioned within the strategies.

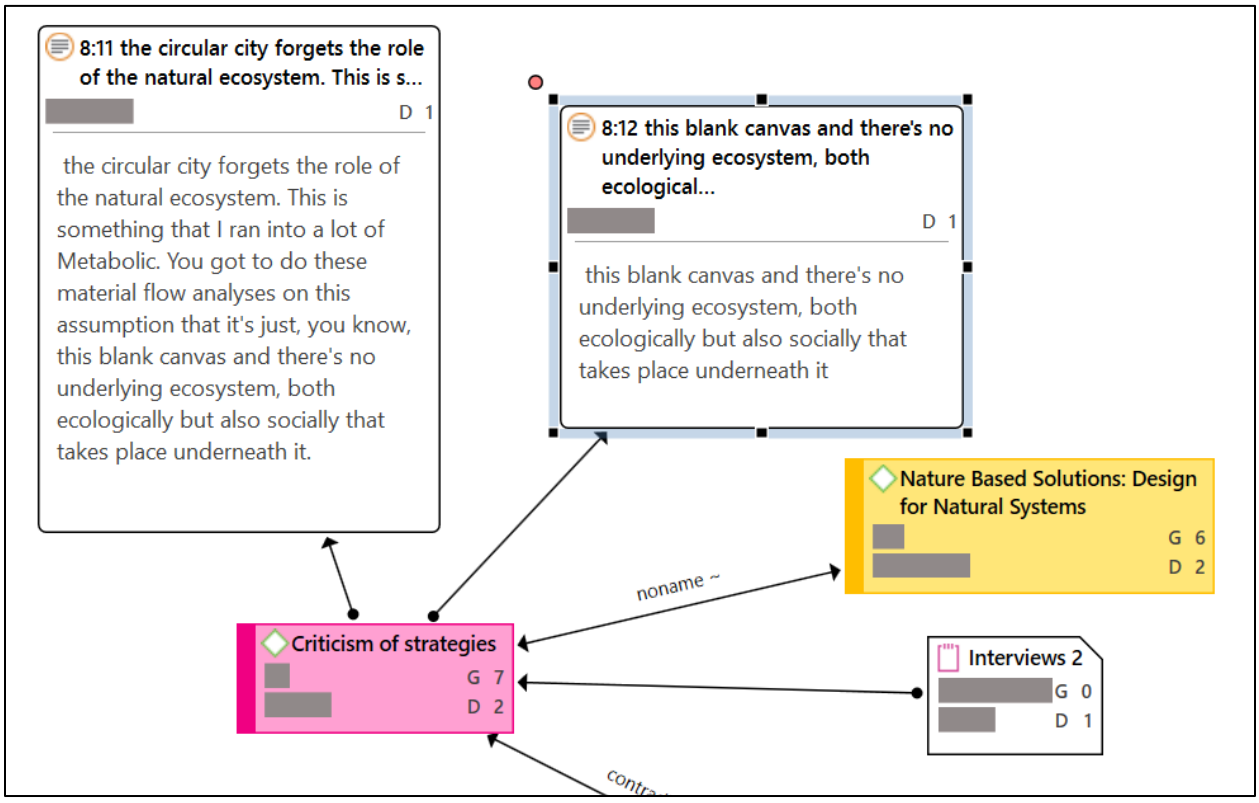


Figure 17 - Interview code-quote Network for Nature Based Solutions noting low occurrences of 'Design for Natural Systems' subcode

Efficiency in the use of materials and resources within the city was a key element of all strategies. Specifically, the recycling of products through the diverse economy and building materials through circular development were prominent. Urban food production land uses associated with recycled organic waste and nutrients from household waste and industrial processes was identified. Resource efficiency in the built environment through decentralised renewable energy systems and water cycling, particularly with reference to the 'cascading' of materials throughout the built environment was a key component of the Environmental Dimension.

As seen in **Figure 12** earlier, both expert interviews confirmed the data revealed with respect to material and resource efficiency and closing local material loops within neighbourhoods. Nevertheless, each expert emphasised the importance of identifying the limits of closed loops and resource efficiency - knowing which loops can be closed, and at what scale, and identifying which loops are too large to be affected at the urban scale.

Recycling and repair of products, decentralised energy systems, and recycling of wastewater locally were identified as critical material loops that should be closed at the neighbourhood scale, with examples provided of the need for experimental "deregulation" approaches to allow for this. In the Dutch context, existing energy and waste processing legislation was raised as a barrier to the implementation of cascading resources through houses within a neighbourhood. Further, these experimental approaches were seen as empowering 'bottom-up' circular initiatives by communities and entrepreneurs.

Urban Agriculture shaping the 'green contours of the City'

In contrast, urban agriculture and food production within the city was an element of all strategies except for New York, noting London was an outlier with three times as many code instances for this theme as other cities. A theme of future land use planning to promote urban agriculture uses for both community and commercial food growing was identified. Efficient food production within the city, utilising technology to implement food production in the built environment, and community growing systems were all presented as key solutions to closing resource loops within the city and reducing environmental impacts of the logistics involved in current food production and consumption systems. This theme spanned across most dimensions of the research framework as depicted in **Figure 18** below.

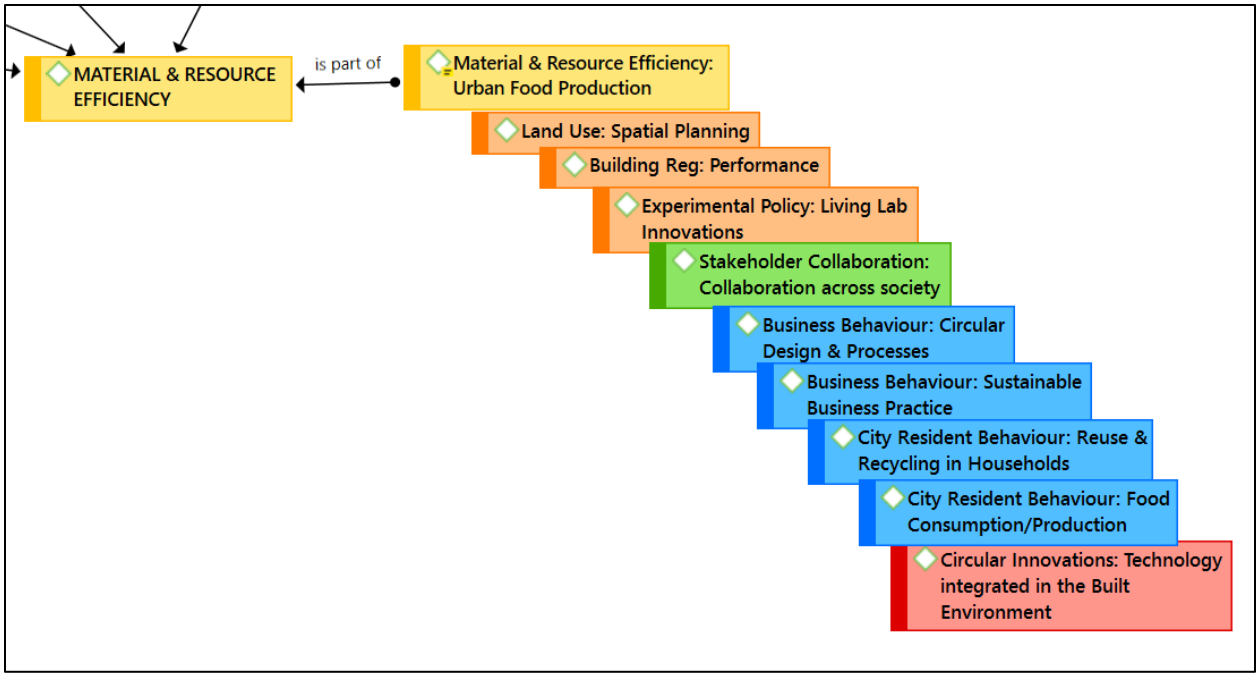


Figure 18 - Code co-occurences amongst 'Urban Food Production' across dimensions

Both expert interviews challenged the strategies' focus on urban agriculture with respect to closing material loops and reducing resource use by producing food within cities. The issues raised included the inability of producing the required food to cater to the needs of city residents without reducing already limited urban green space, with concern raised for the quality and amount of urban green space being impacted by this concept. It was raised that urban agriculture is spatially intensive in that it requires significant land for growing, processing and packaging, as well as storage, with these elements generally not considered within the strategies.

The ability to meet the nutrition needs of city residents by urban agriculture was also challenged, with Expert #1 disputing the potential yield of urban agriculture and identifying that the types of foods that are capable of being produced in urban settings exclude common crops such as potatoes, wheat and rice which make up the majority of people's diets. Commercial businesses utilising urban-grown produce was challenged with a similar argument. The improvement of existing food production processes was prioritised above urban agriculture, noting the Netherlands specifically contains highly productive farmland within close proximity to dense urban centres.

Nevertheless, the experts did identify potential utility in urban food production in the CC. The use of under-utilised building space was identified by Expert #2 for potential adaption to urban agriculture to preserve valuable open space in cities. Expert #1 suggested a strong link between urban agriculture and positive social functions such as knowledge building and inspiring children and residents towards healthier diets, as well as connecting neighbours through community garden initiatives. Concern was raised with the potential abuse of shared food production in cities such as 'food forests', citing existing examples of such initiatives within Amsterdam.

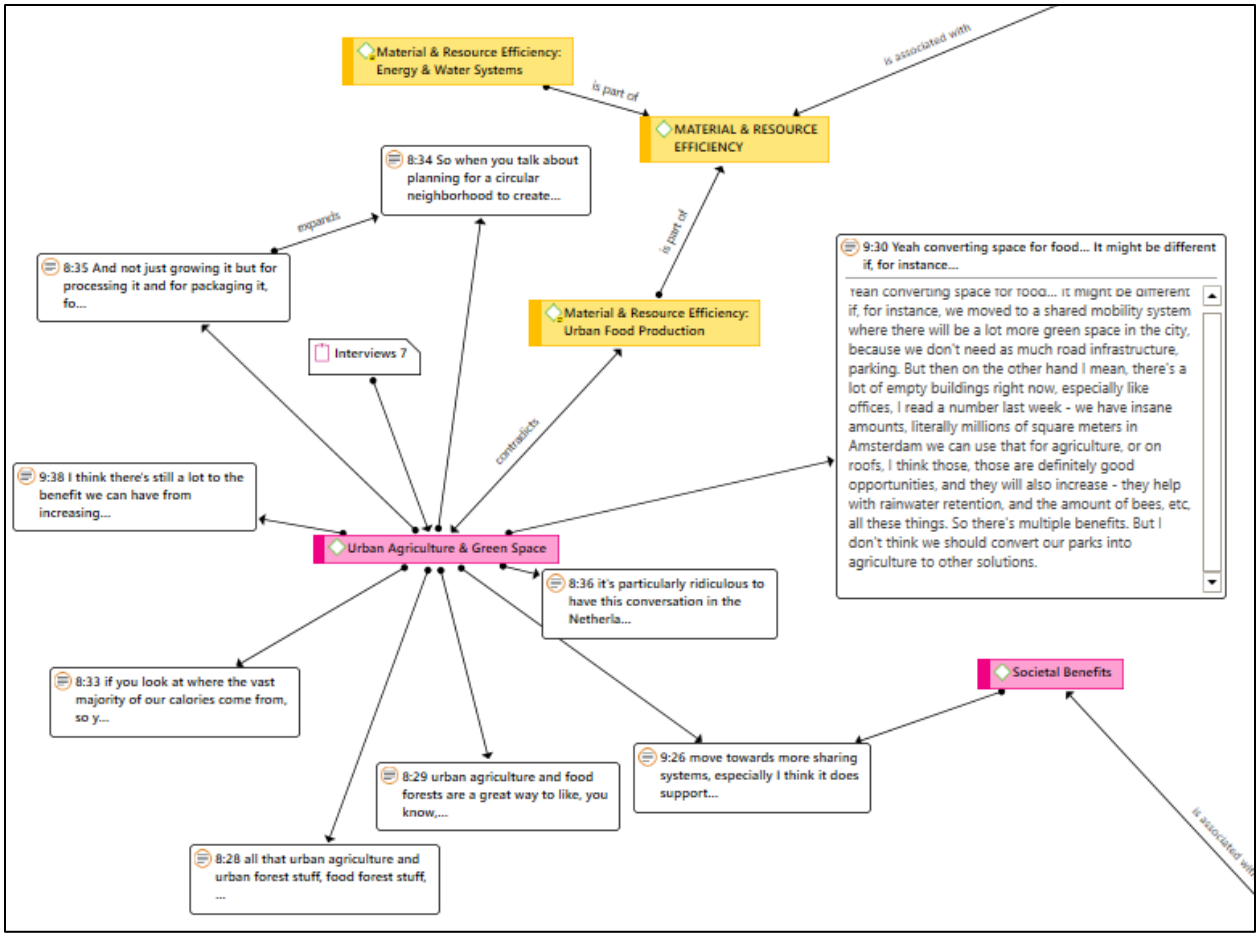


Figure 19 - Interview code-quote network for 'Urban Agriculture'

7.4 Behavioural

A substantial onus is placed on the residents of the city within most strategies with respect to reducing consumption and waste at the individual level. In combination with sustainable business practices and businesses engaging in new revenue models, the CC relies significantly on the behaviour of both its residents and its businesses to ensure circularity.

Household Responsibility

The elements of the Behavioural Dimension within the Pomponi Framework were initially divided amongst resident and business behaviour within the circular city. The document analysis revealed that residents within each strategy were a key driver towards a transition to the circular city. Awareness of consumption habits amongst city residents are instrumental in engaging with and supporting the sharing economy, repair and recycling services, and reducing purchasing of new products to be replaced by leasing through product-as-a-service models.

Further, citizen 'ownership' over the functions of households and neighbourhoods was promoted. Citizens engaging in the management of recycling infrastructure and participation in recycling programs or for food production within their neighbourhoods. The goals of each strategy were to strengthen the link between residents and their food for two reasons: to increase consumption of locally sourced, sustainable food (primarily plant-based) but also as a driver to change food waste and consumption habits. In combination with a shift in responsibility towards households with respect to their waste production through increased in-house waste sorting, composting, and recycling. Residents within the circular city are envisioned to hold a greater responsibility over their waste and consumption habits.

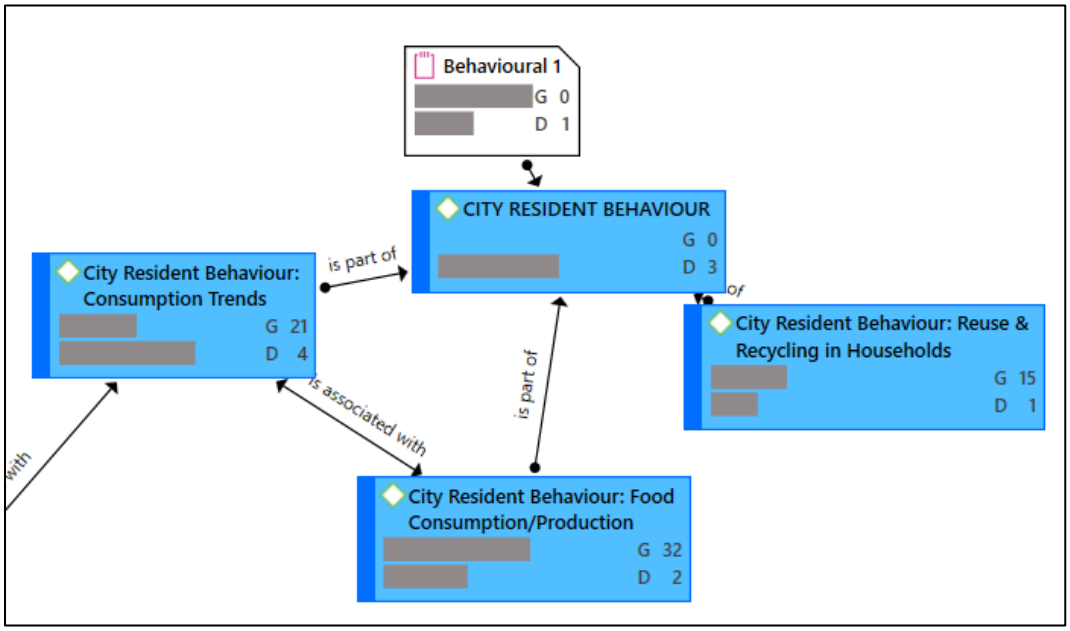


Figure 20 - Code network for 'City Resident Behaviour' with frequency of occurrences indicated

A disconnect between implementing strategies and their focus on changing resident behaviour was raised in Expert Interview #1. This criticism provided that while larger material flows can be

identified within the city at the level of a circular transition strategy, and solutions can be presented to close those loops, the impact of the CE transition upon city residents was not well-communicated and difficult to confirm. The interviews suggested that rather the main causes of wasteful resource loops in the city were difficult to address through changing resident behaviour.

Producer Responsibility

Similarly, all strategies concentrated on the expansion of producer responsibility with respect to material and resource use, and facilitation of the circular economy. Business behaviour variables included themes related to "*Sustainable business practice*" and "*Circular Design & Processes*". Both themes evenly occured across the documents as seen in **Figure 21** below.

	Business Behaviour:... 26	Business Behaviour... 32	**Totals**
1: Amsterda... 145	1	7	8
2: Basel Strat... 106	6	3	9
3: Bern Strate... 90	2	1	3
4: London St... 120	7	9	16
5: New York... 116	7	8	15
6: Paris Strat... 84	2	2	4
7: Rotterdam... 67	1	2	3
Totals	26	32	58

Figure 21 - Code-document co-occurence table for 'Business Behaviour'

The business of the CC is to reduce its overall waste production and material use through effective use of resources by engaging in product-as-a-service models, with the incentive of reducing its long-term costs and generating new revenue streams. Simultaneously, an extended producer responsibility and closer and longer relationship between consumers and producers within the city is envisioned. In these models, businesses are more aware of the use of their products and are financially tied to their maintenance and longevity, a form of economic incentivization towards circularity. Businesses are to collaborate with each other to maximise logistics sustainability, and form synergies amongst each other to reveal new avenues for production and resource sharing.

Further, the design of packaging, products, and processes towards circularity is a key of business behaviour within each strategy. Combined with guidance from knowledge from educational institutions, government and consumers, businesses are enabled to engage in the CE transition. New business models in clothing, furniture, and sale of food will shape the economy of the city, all driven by behaviour of businesses in the city.

7.5 Societal

The initial operationalisation of the research framework placed an emphasis on broader societal trends such as urban mobility and collaboration amongst communities within the CC model. The document analysis provided a previously unanticipated insight into the forms of societal collaboration required to transition to a CE, the type of sector-spanning knowledge and capacity building required to initiate the transition, as well as the social benefits of the concept.

Circularity through cooperation

Three forms of stakeholder collaboration were identified within the document analysis as parts of visions for circular neighbourhoods. Collaboration across sectors of society, including between business, communities, and government were key to enacting a transition across each strategy. 'Public-private partnerships' a form of cross sector collaboration are critical for land development and renovation of existing buildings, and supporting markets for reuse of building materials across development projects. This form of partnership was also instrumental to living lab approaches, participatory planning processes, and with respect to closing material loops between business and societal activities. Food production and reuse of food waste between businesses and residents is also envisioned to be facilitated by government organisation. Specific collaboration between government and business was a distinct theme across all strategies, and whilst not prevalent throughout each document, it largely related to the shaping of business behaviour and processes through voluntary agreements and innovative partnerships to shape design of products for returnability, repairability, and compostability to fuel diverse economies and closing material loops.

Knowledge and capacity building forms a large part of the behavioural and economic change envisioned for the city. This was not originally considered as part of the theoretical conceptualisation, and its frequency across the analysis was similar to the planned collaboration across societal sectors. Engaging with educational institutions, connecting community projects with knowledgable parties, and sharing experiences learned through 'toolboxes' and 'handbooks' is to be applied to encourage the upscaling of circular projects from innovative experiment to broader implementation. Professional networks of planners, architects, and builders, with research organisations and consultancies are to share business cases for the use of secondary materials, design with their use in mind, and shape future criteria and standards to be implemented by Government in future development. Finally, education and awareness raising campaigns to shape resident behaviour, as well as teaching circular principles in university and vocational courses to prepare students for future economies was identified.

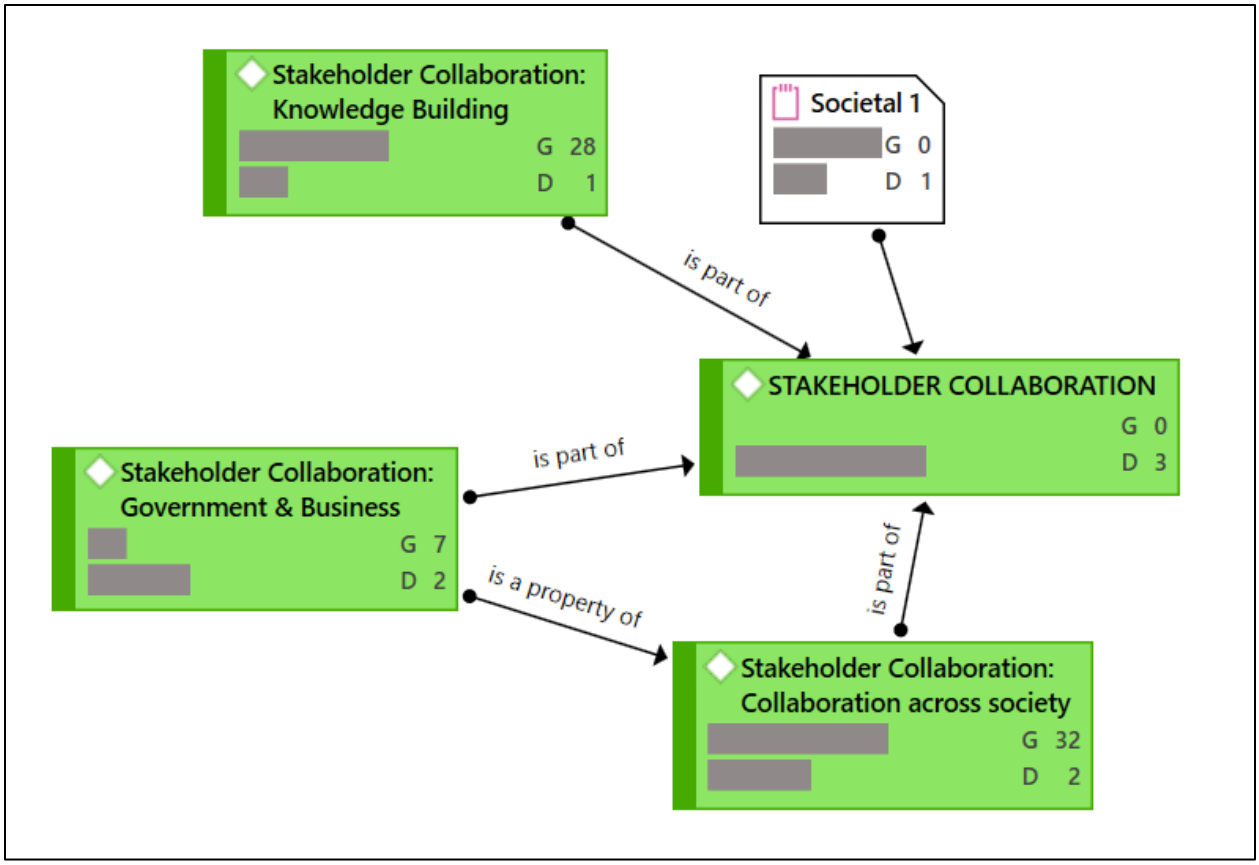


Figure 22 - Code Network for 'Stakeholder Collaboration' indicating higher frequencies for cross-societal collaboration and knowledge building

Beyond sustainable transport – fundamental and fair public services for all

Whilst sustainable transport trends were identified in most strategies, they generally focused on electrified public transport, walking/bicycle infrastructure, and the closing of resource loops in transport. Examples of electric vehicles contributing to a renewable energy grid or the use of biofuels in bus fleets collected from organic waste were presented as societal transformation across the realm of mobility. Circular mobility was otherwise not a considerable element of the strategies as originally anticipated in the theoretical conceptualisation.

The expert interviews acknowledged that a focus on the design of neighbourhoods to exclude private vehicles would likely have an unequal impact upon different social groups. Particularly noting the socio-economic link between living close to employment and services, with lower socio-economic areas likely to have a higher use of private vehicles due to their increased distance from economic centres and essential services. Shared mobility services such as 'car share' programs were described as a solution to this issue, also potentially returning more functional space and recreational green space to inhabitants through reduced parking and road infrastructure in neighbourhoods.

All strategies purported the social benefits of the circular transition and envisioned a large role of the CE in contributing to social equality. Closing of material loops in food systems, and collaboration between communities and businesses were envisioned to be paired with social movements such as 'communal fridges' and redistributing surplus food supply to those in need. Further, diverse economies would improve access to affordable consumer goods through sharing/repair platforms and second-hand product markets, while renovation initiatives in social housing and private stock would result in reduced living costs with respect to energy consumption and building performance - with this planned to have a greater impact on poorer households and improve their "financial opportunity" (Amsterdam Circular 2020-2025 Strategy). The reuse of building materials, particularly with respect to renovation of public buildings such as hospitals is able to link secondary materials and building appliances with social housing to ensure lower income households are provided with products that have not yet reached end of life.

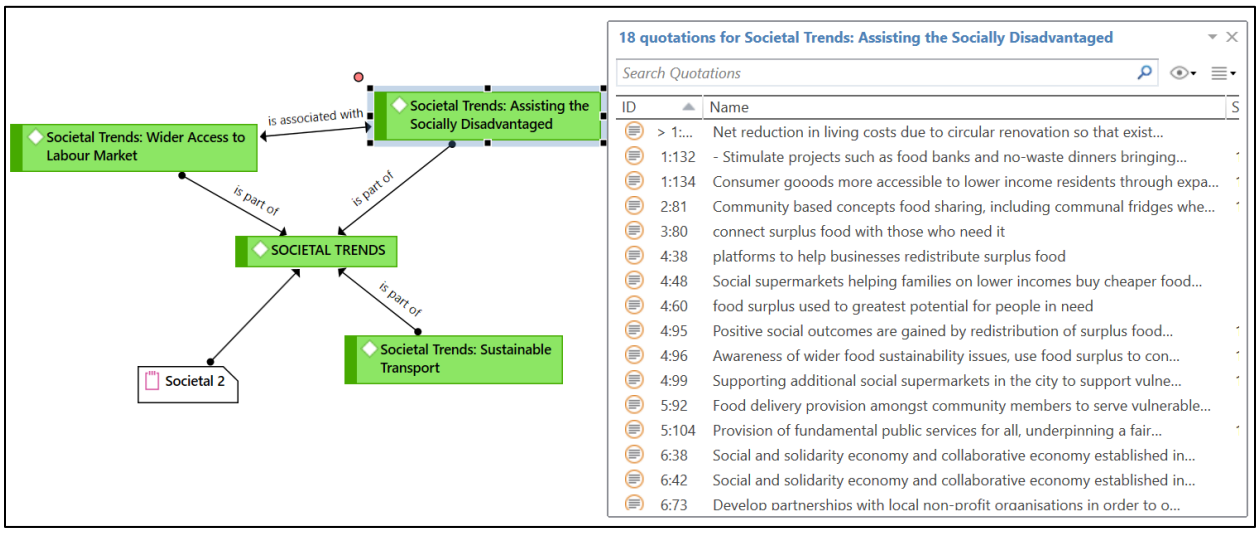


Figure 23 - Quotation links to Code 'Assisting the Socially Disadvantaged'

An Economy for Everyone

Additionally, social trends with respect to a new and expanded labour market within cities was expressed across all strategies, with this not considered as part of the initial thesis operationalisation. Vocational training and upskilling for roles within new repair and recycling sectors, including digital training for vulnerable workers to integrate the diverse economy with the technology sector were a key element of the circular city. A more balanced labour market within cities, that addresses challenges of non-unionised and unregulated work in the CE would allow for the reintroduction of long term unemployed, disabled people, or reintegrated offenders into 'reshored' activities, as well as a larger pool of low-skill jobs that require minimal training. This wider labour market in combination with small-scale circular activities including non-profit activities across neighbourhoods would serve an improved social function by providing opportunity for interaction amongst those who do not work, and by linking professional workers with blue-collar workers through repair and recycling of electronics and appliances close to residential areas.

The positive social benefits of small-scale recycling and repair and sharing economy platforms was voiced by both experts at **Figure 24**. Building social connections amongst skilled tradespeople and residents in the city, providing wider access to the labour market, and connecting community members through sharing platforms were presented. This was a concept identified within the document analysis, with sharing economy and product-as-a-service models planned to reduce economic burden on lower income households by increasing access to products and services by removing the barrier of product purchase to access services.

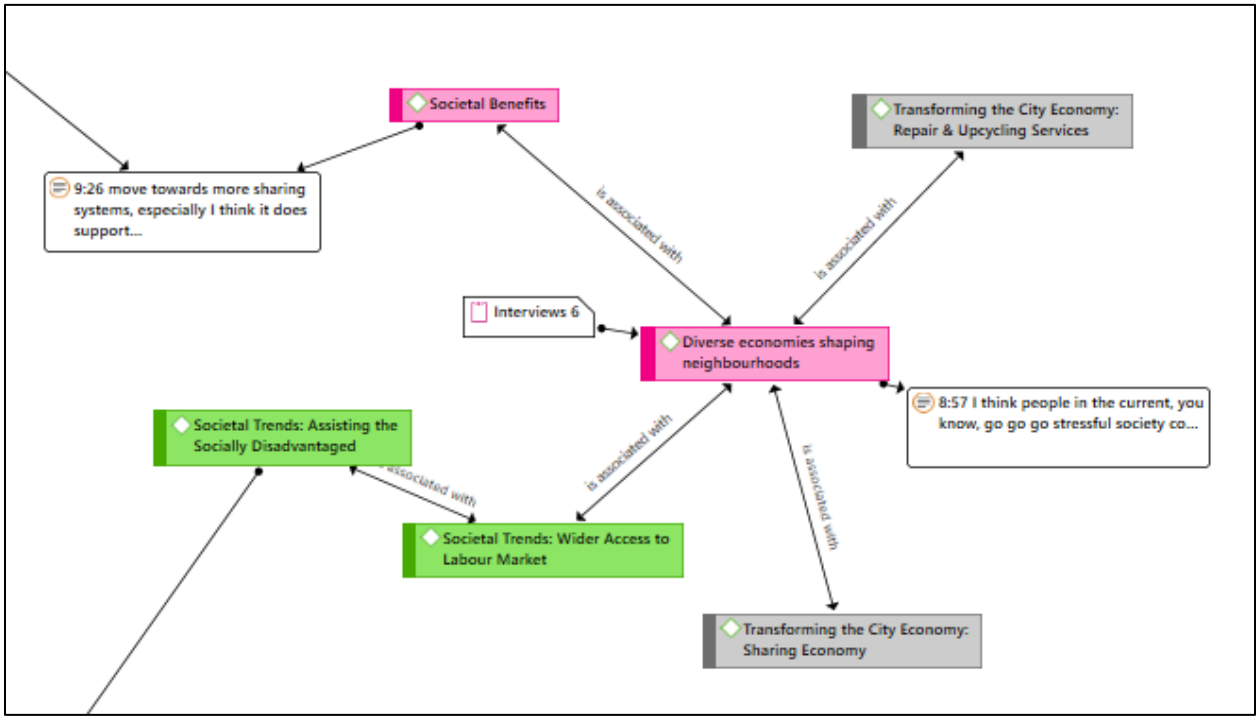


Figure 24 - Interview Code Network for 'Diverse Economies'

7.6 Technological

The document analysis revealed technology as a large factor in enabling the planned circular activities and material flow measurements of each strategy. All strategies imagine a city whose environmental impact and resource use is constantly monitored, with this data accessible for government, business and the public. Innovative technologies applied in the fields of waste recovery, production, and the built environment are also a part of the CC.

Innovation in the Circular City

The two variables identified within the original operationalisation were reorganised and expanded during the document analysis process. The concepts of "*Circular Innovations"* and *"Urban Metabolism:* were inexorably linked, but a distinction was made between the two in that innovations largely related to novel technologies in the CC including their integration into the built environment. Alternatively, the urban metabolism relies on the sharing of open data about the city's material flows and a more concentrated focus on the 'urban mine' - the culmination of all materials contained within the built environment, including its potential 'end of life' and associated initiatives to ensure these materials are recirculated within the city.

Technological innovations in waste recovery and new production systems which facilitate the closing of material loops were evenly represented across all strategies. These concepts included the extraction of value from waste sources to produce new products, including for building materials, pharmaceuticals, or product packaging. Chemicals extracted from wastewater for use in biofuels, production of fertiliser, or enhanced fibre recycling to change unsustainable clothing production are all represented.

	1: Amsterda... 145	2: Basel Strat... 106	3: Bern Strat... 90	4: London St... 120	5: New York... 116	6: Paris Strat... 84	7: Rotterda... 67	Totals
Circular Innovations: Digital Tools 27		5	4	6	6	3	3	27
Circular Innovations: Production Technologies 14	3	1	2	2	4	1	1	14
Circular Innovations: Technology integrated in th... 14	2	2	6	3	1			14
Circular Innovations: Waste Recovery 19	4	2	4	3	1	1	4	19
Totals	9	10	16	14	12	5	8	74

Figure 25 - Code co-occurence table for 'Circular Innovation'

The integration of technology into the built environment ranged from the planned growth of innovation at the building scale, to more visionary examples of the neighbourhood of the future. This category involved high technology food production incorporated into existing buildings such as vertical agriculture with a lower environmental footprint. Further, neighbourhood design is to incorporate decentralised renewable energy systems and redistribution of waste streams amongst buildings for 'cascading' of resources throughout building functions – linking waste heat and recycled water amongst neighbourhoods being two examples. Smart digital solutions were encouraged to enable the management of activities in the built environment such as energy production and storage, building maintenance, and urban material mining with an example of these processes facilitated by sensors, machine learning and smart robotics.

Expert #1 provided insight into the implementation of digital tools for the management of the natural environment within cities, given their background in research on the topic of smart urban

green space and the 'Internet of Nature', Particularly, this interview identified the use of technology to mitigate resource use in managing urban trees - sensor technologies in combination with community apps allowing for neighbourhoods to monitor the health of trees and water them when required. This form of technology was also promoted as providing a social engagement between city residents and urban green space, beyond the urban food production focus of the strategy documents.

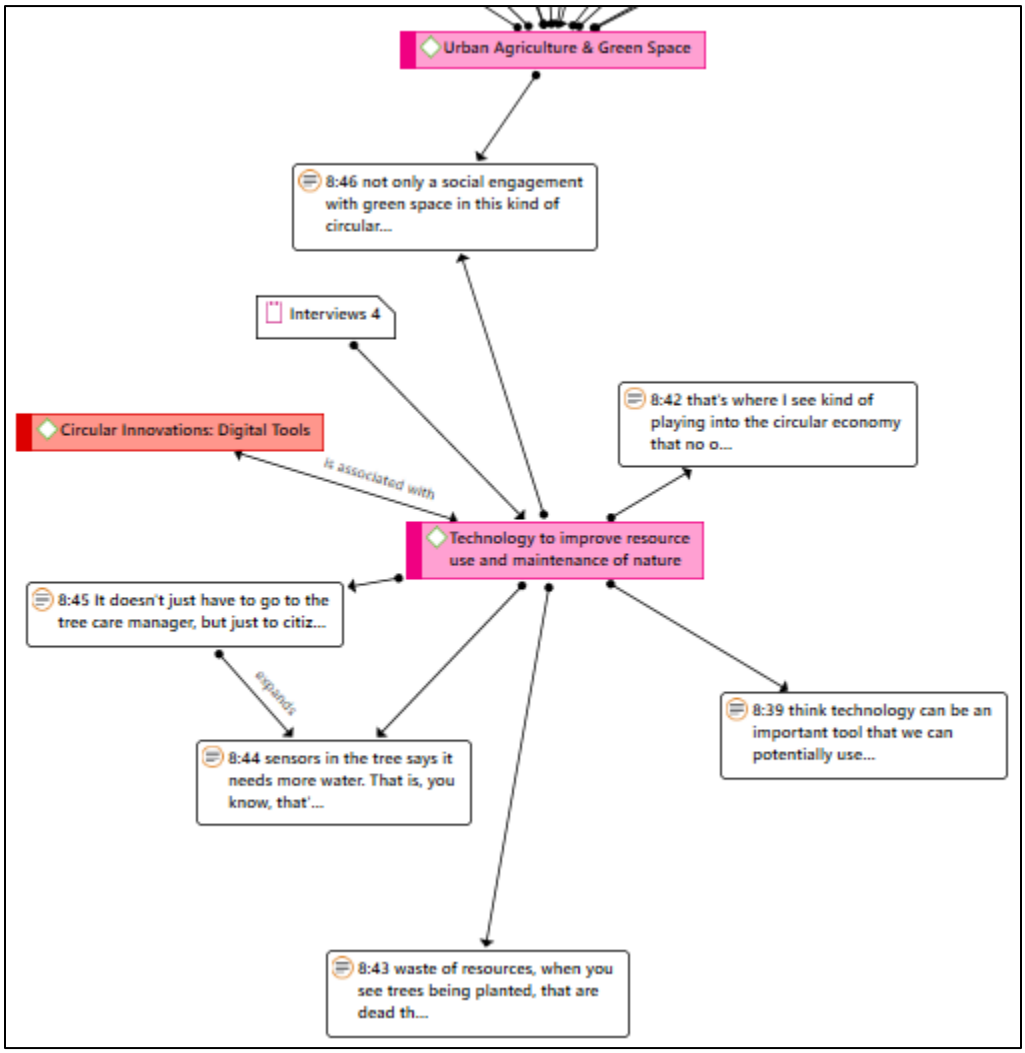


Figure 26 - Interview Code Network for the use of digital tools in environmental management

The use of digital tools was not previously incorporated into the research framework. This theme was contained across 6 of the strategies, and included apps, information technology, or other digital tools that enable participation or otherwise support circular activities. Providing access to CE business models/platforms, reducing waste, or sharing products is all closely linked to digitisation. Apps for the CC revolve around digital currencies that support sustainable consumption behaviour and avoiding food waste but also enable participation in the sharing economy and new product-as-a-service models. Software tools largely involved digital platforms for the trade and sharing of secondary waste materials within the city in the realms of construction, small scale repair and recycling, and electrical products or furniture to enable the recovery of

products after their first lifecycle. One example of blockchain technology implemented into supply chains to minimise food waste and transport pollution was included.

Measuring & shaping the Urban Metabolism

The urban metabolism was a variable of the Technological dimension due to its inherent reliance on technology, particularly with regard to building information modelling and the collection of large amounts of data to represent the material flows and inputs/outputs of the city and its functions.

In the first instance, the collection of data related to material flows and its sharing in open access platforms was critical to each strategy as a way to enable CE markets and the sharing of materials across communities. Future regulation and performance indicators implemented at the Government level require accurate and current indicators of material flows. The sharing of data allows for collaboration across businesses with respect to supply chains and logistics, amongst citizens in trading and sharing products, and amongst development industry to bridge the gap by matching demolition materials to new construction sites. This variable when applied to the neighbourhood included one strategy describing the concept of a "quantified community" that combined the use of 'big data' collected through sensors to design context specific solutions to communal challenges such as waste elimination, but also to provide decision-support for communities in promoting sustainable behaviour (Circular Cities Switzerland: Basel). In this way, the urban metabolism and its sharing across the city will shape both top-down and bottom-up approaches to circularity.

Urban mining, whilst closely linked to open data sharing, spoke specifically to data related to the built environment and the presence of usable and accessible secondary materials from development projects. The concept involves the combination of building information modelling - building a record of materials used in construction of a building, with an open database that can facilitate the planning of future development based on the availability of materials within buildings that require demolition. In combination with digital marketplaces and localised logistics spaces, this theme was key in closing material loops in land development of new areas and building renovation of existing building stock.

The importance of identifying and monitoring the "urban mine" in the circular city was confirmed through the expert interviews. Particularly, the facilitation of open data platforms and modelling the value of stored materials in the built environment by Municipal Governments to enable secondary material use within the development sector was emphasised. Specifically, the use of this data would play a significant role in transitioning buildings towards circularity: shaping planning and building regulations, encouraging architectural design trends through designing based on available secondary materials, and by quantifying the need for logistics and storage spaces within the city for building materials.

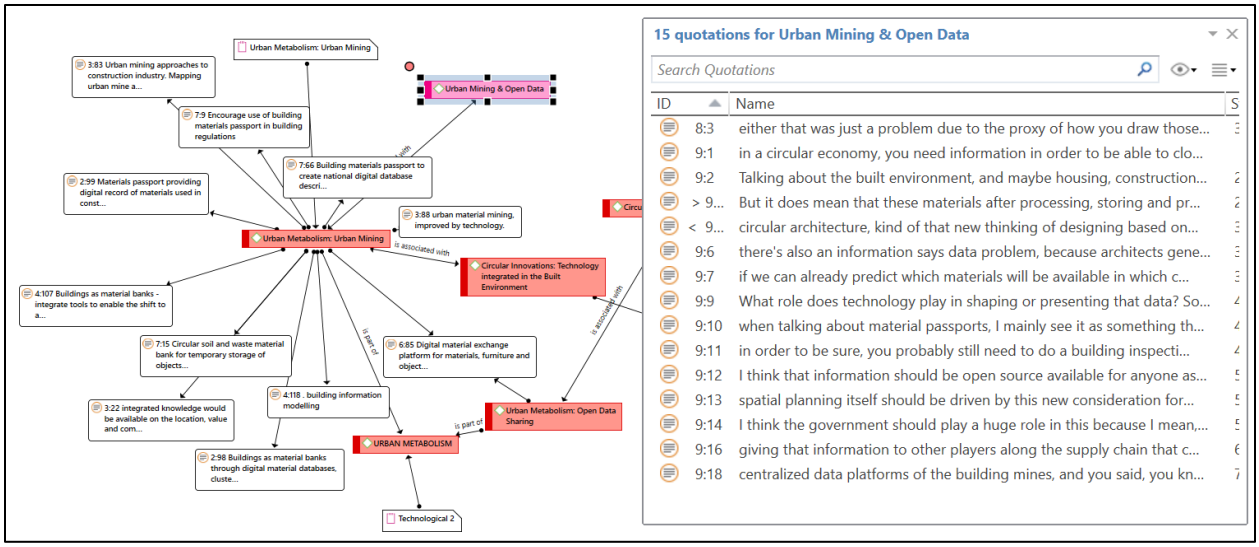


Figure 27 - Code-quotation Network for Urban Mining, with tabulated quote list from Expert interviews

8. Answers to Research Questions

The transition to a Circular City across urban centres throughout Europe and the world will require transformation across different dimensions of the built environment and its functions, actors, and finance and governance structures. This research utilised an existing research framework that was adapted to conceptualise and link the various dimensions of the CC, with a specific focus on the neighbourhood as a unit of the city. In seeking to characterise the 'circular neighbourhood' and the implications and requirements of a CC transition at the scale of the neighbourhood, this research was able to distinguish the elements of the CE, and CC strategies that will shape neighbourhood development, spatial and land use planning for neighbourhoods, resident and business behaviour, societal trends, and technologies within the city.

The following sections detail the results gathered from the document analysis and expert interviews in answering the research questions. Following this a second round of input is provided against the results and answers to research questions, as part of the Delphi process with one of the experts previously interviewed.

8.1 "The City as Neighbours" – Answering research questions

The Atlas.ti code analysis tool was used to answer the research questions by linking relevant variables for each question across dimensions and framing the results with reference to each research question. This section links the results of the research to the research aim.

The cross-dimensional findings described within the results are used to answer the research questions below.

- *How is the circular city interpreted at the scale of housing and the neighbourhood?*

The CC involves a holistic transformation of both existing planning processes, construction and performance standards, and resident behaviour at the level of the household. Future development of existing housing stock should favour the retention and adaptation of buildings rather than demolition for recovery of secondary materials. Regulations will shape business behaviour and seek to renovate and retrofit housing to improve its energy and resource efficiency, including the integration of renewable energy systems and cascading of waste flows between buildings. Barriers to converting existing housing stock in the CC include current financial models with respect to private land development, including the cost-profit model of rental housing.

New housing is to be designed through planned synergies amongst buildings to close all local material loops where possible. Construction will be based on the availability of secondary materials through the 'urban mine' with houses designed for deconstruction and adaptability in future. Taking best practice examples from 'living lab' approaches, new housing development will involve decentralised energy systems where houses generate their own electricity and power a shared grid. Organic waste and wastewater will be collected and processed locally where possible and repurposed for application in management of green space or energy production, and ideally symbioses between industrial uses within the city and new housing to allow for sharing of waste heat or organic waste to serve the broader functions of the city.

Neighbourhoods of the circular city will be shaped by a diverse mix of land uses and functions. The reliance of the CC upon the diverse economy to reduce resource consumption and waste production requires the co-location of repair/upcycling economies employing a wider range of the labour force within close proximity to users. The circular neighbourhood will combine a variety of land uses including diverse economies, traditional commercial premises, housing, and public open space to minimise the distance between material flows and to stimulate closing of loops in production and consumption. This will logically require higher density forms of housing to maximise the use of space and proximity between material flows – creating a relationship across uses: "the City as Neighbours" (Rotterdam Circulaire 2019). Sharing of buildings across residential, office, and commercial uses would allow for constant use of buildings and mitigate the need for new urban development.

- *How does a CE transition in the city address residential neighbourhood development?*

A shift in financing of land development is required to enable the circular neighbourhood. Financial incentives and disincentives will stimulate circularity in urban development by funding circular activities and public construction or reducing current financial barriers to the use of secondary materials in land development. Taxes and fees for the use of virgin materials and landfilling of waste from projects will discourage current development trends. New neighbourhood development will be encouraged through collaborative initiatives, incentives based public funding, and new revenue models upscaled from experimental living lab developments. The potential 'gap' between implementing these forms of incentives and practical application will require significant top-down intervention to enable a transformation in current development models.

Residential neighbourhoods will be developed based on shared data on the availability of secondary materials, particularly with respect to the 'urban mine' and release of available materials from within the city. New markets in trading of secondary materials will be created that will support circular development. Indicators and material use data collected through integration of monitoring technology throughout new developments will quantify their lifetime environmental performance, with this to be a consideration of planning permission granted to development.

- *How will residential land uses in the city be shaped by Circular City strategies?*

Residential land uses will likely be focused in higher densities forms and integrated with mixed economic and social land uses. Localised small-scale repair/upcycling services will service residents, with share economy platforms encouraging the greater use of tools, furniture, and other household products amongst neighbours. Local food production integrated into the built environment, whilst a larger focus of CC strategies will likely be smaller scale. They will largely serve a social function through community gardens that supplement existing food consumption trends rather than replace existing production methods. Their co-location amongst residential land uses will serve to encourage a shift in resident behaviour towards more sustainable food consumption, less food waste produced, and separation of household waste to ensure use of valuable organic waste is maximised.

The impact of societal collaboration and participatory planning processes on shaping the circular neighbourhood was discovered throughout the document analysis. Specifically, residential land uses will be a result of community formed circular ambitions, advised by 'big data' collected from

existing neighbourhood functions and new participative democratic models for financing circular development and changing neighbourhoods will emerge. A focus on affordable housing will result in modular and adaptive construction contributing to the diverse housing needs of city residents. Circular developments will focus on the growth and integration of social housing, and the shared occupancy of spaces as a solution to unaffordable rents and land prices. This trend is largely consistent with the unanticipated connection between CE transition in cities and positive social impacts upon society, particularly the socially disadvantaged. Whilst affordability through renovation of social housing might not result in reduced living costs, larger focus on reduced food waste and social initiatives such as community supermarkets and non-profit sharing economy services will have a proportionate impact upon the socially disadvantaged within the city.

- *What does Circular City implementation entail for housing?*

The behavioural shift required in households to enable the CC transition revolves around the reduction in consumption and waste production, separation and use of valuable waste, and engagement in the diverse economies available to residents within their neighbourhoods. This change will be enabled using digital tools such as apps or digital alternative currencies, to promote sustainable behaviour and engage in product-as-a-service platforms which will include the leasing of currently owned features of the house such as lighting, furniture or appliances.

As discussed previously, food production integrated with housing will be a shared function amongst neighbours with the goal of supplementing current food consumption and raising awareness of environmental impact of households, while building social links amongst residents. Finally, the integration of technology within houses will form a stronger link between residents and the environmental performance of their houses. Small-scale renewable energy systems contributing to a shared power grid, water reuse systems and shared mobility schemes will likely demand a more time-intensive involvement in the day-to-day management of one's house. The resident of the circular neighbourhood is expected to be involved in community food production, the environment performance of their home, whilst also being conscious of their current consumption habits.

- *How do bottom-up approaches to the CC reflect the circular 'principles' contained within CC Strategy documents?*

Bottom-up approaches as discussed during the expert interviews largely involved experimental approaches to introducing circularity within neighbourhood development projects, and require deregulation approaches to allow for innovative solutions to current resource use challenges. These approaches were largely reflected within the CC strategies, which focus on the up-scaling of approached through knowledge-sharing of 'circular toolboxes' and 'handbooks'. The growing body of experimental approaches will allow for a collaborative approach to building universal planning and building regulations that embed circular principles into current land use processes. This will involve stakeholders across municipal government, private architects, and developers to ultimately shape provisions that will promote circularity whilst being practicable in implementation during construction and demolition of buildings.

The collaborative and 'grass-roots' approach to living lab experiments was also reflected in the strategies, with communities expected to guide the future circular ambitions of their homes and

neighbourhoods. Government enabling of these approaches will be required through interaction and cooperation across stakeholders from communities, private developers, and businesses.

8.2 Final feedback from Delphi process

In accordance with the Dephi method, a second round of feedback from an expert was provided after their review of the research results and discussion sections detailed previously. The expert was presented with the results which included an aggregation of the interview data and opinions received from both experts, and additional feedback was received in written form. The additional feedback was provided in response to Section 8.1 where the results were applied in answering the research questions.

The second round of feedback was provided in an informal structure – email response, and provided further views of 'Expert #1' related to the interpretation of the results when applied to the research questions. This feedback is provided at **Annexure 6** of this thesis. Table 5 below provides a summary of the additional feedback against each research question, and a reflection upon each response and any additional knowledge that can be gained from the response.

Table 5 – Second round expert feedback

Expert #1 Second Feedback	Reflection/Comment
· How is the circular city interpreted at the scale of housing and the neighbourhood? *In terms of density in neighbourhoods, it is true that the Circular City has certain spatial implications that would require higher densities to fulfil all its needs and functions within a small area. This would be the only way to do it while avoiding urban sprawl, but there is a balance in keeping the Circular City liveable and a nice place to be. High-rise neighbourhoods with closed materials loops in waste management, food production, and cascading of resources might achieve Circularity but if they are not nice places to live, it defeats the purpose of the CE transition. A higher density is definitely a need for any future direction of sustainable development, but this needs to be balanced with the neighbourhood feel and livability of the city.*	The expert feedback in response to the 'answer' to this research question acknowledged the theory that the circular neighbourhood as interpreted from the strategies would have spatial implications requiring higher densities to accommodate the envisioned mixed uses, building synergies, and overall resource and material closed loops. Nevertheless, the expert feedback emphasised the need to ensure neighbourhoods are 'liveable', and that higher densities in cities do not compromise the amenity of residents within their neighbourhoods. This concept was not previously identified throughout the literature review but is similar to the societal themes identified within the document analysis. Specifically, the strategies emphasised social links amongst communities with respect to sharing economies and redistributing surplus food. Whilst not directly linked to 'liveability' these themes make up part of the circular neighbourhood with respect

	to how residents experience and interact with the neighbourhood.
· ***How does a CE transition in the city address residential neighbourhood development?*** *It is interesting you mention collaborative initiatives here and crowdsourced land development models in your results. A current project at Metabolic has started a similar circular housing project after 4 years with a group of consultants developing their own housing corporation and have begun building recently. I think if the process of crowd-driven development becomes easier (not 4 years!) I think these models will only become more popular.* *In terms of pilot models and living labs I think these play a large role in the Circular City but at some point require scaling up – they shouldn't stay as pilots forever where the financial element of the project never comes to fruition. With the previous example, I know Metabolic crowdfunded a lot of it, as well as 'crowdlending' that was able to provide a return in interest to any investors in the project.*	The expert feedback focused on the new financial models for funding circular land development that was revealed during the document analysis. An example was provided of a circular consultancy which has recently carried out an experimental housing development through crowd-funding but acknowledged that the process is still novel and difficult to implement. A new model that was not revealed during the research was that of 'crowd-lending' which would provide a financial return to crowd funding participants in living lab developments.
· ***How will residential land uses in the city be shaped by Circular City strategies?*** *I like the concept of the use of 'big data' to shape neighbourhoods – I think the more things that are measured the more can be learnt, and it has an added benefit of raising awareness to people's consumption habits in the neighbourhood if that information is relayed back to them. These initiatives can deliver greater ownership to citizens of their impact and use of resources in day-to-day life. Ideally, if people are open to data sharing which I think would need to be anonymized at neighbourhood scales due to privacy, you could perform neighbourhood scale analyses which would serve as the baseline for any circular intervention or campaign in the neighbourhood.* *From my experience with Treemania and using soil sensors was that tree managers*	Quantifying material flows within neighbourhoods and residential behaviour was identified as a key element to raising awareness towards circular behaviour amongst residents within the cities. The concept of 'ownership' of the neighbourhood by its residents was raised in the feedback which would provide a greater link between residents and their consumption habits. Further, the broader use of open data across neighbourhoods was identified a critical to shaping community ambitions with respect to circularity. Whilst these community-driven visions and projects were identified in the results, the expert's feedback raised the use of open data as a 'baseline' to approaching any future vision for neighbourhoods. This provided a good insight into the process identified in the results, as communities will need to make informed decisions about their

would report that they had been over-watering trees when our sensors indicated that they were structurally under-watering. It provides a good insight into the value of data in resource efficiency and raising awareness. I think measuring data in neighbourhoods will allow for more experimental approaches and provide residents with greater ownership of their communities.	future circular ambitions and this requires an accurate knowledge of the resource use within their neighbourhoods.
· What does Circular City implementation entail for housing? *This is similar to the above.*	The expert did not provide feedback to this research question, indicating that potentially the question was similar to others or did not provide additional insight into the research. It is considered that the expert's feedback regarding the use of data in shaping resident behaviour also addressed this 'answer'.
· How do bottom-up approaches to the CC reflect the circular 'principles' contained within CC Strategy documents? *The most important thing in developing the circular city is creating the spaces for circular experiments to grow organically, similar to the concept of 'place-making' in spatial planning. If you create the spaces for experimentation through spatial design you could encourage communities to organise projects and connect with neighbours even without instructions, but they need the space for these processes. Like I mentioned above I think there is a danger in planning for high rises only to close material loops you will lose interactions at the street level and amongst neighbours.*	The expert raised the need for spatial considerations when planning for circular neighbourhoods, which is reflected in current living lab approaches. The design of urban areas to facilitate experimental approaches and collaboration across neighbourhoods was not identified within the results. This concept could serve as a 'missing link' between planned living lab approaches and their application to larger areas within the city. Rather than seeking to scale up the approaches of a living lab across greater spatial scales, the design of neighbourhoods to facilitate this collaboration is a new concept that had not been revealed in the document analysis.

The answers to the research questions and additional feedback against the findings of the research contribute to the following section containing discussion and conclusions of the research.

9. Discussion & Conclusion

The following section of this thesis provides feedback and generalisations to the adapted Pomponi Framework, including addition of new concepts and outliers that had not previously been considered. Then it positions this research amongst current academic literature, details limitations of the research, and its relation to future explorations on the topic. Finally, a concluding statement is provided including recommendations for practice on the topic of spatial planning for circular neighbourhoods.

9.1 Generalisations / Feedback to Adapted Research Framework

The results of the research allow for a reflection upon the conceptual framework – adapted Pomponi Framework and to present generalisation of the results and suggestions to the framework. Outliers, previously unconsidered elements of the circular city, and new insights provide for additions to the framework potentially contributing to future research on spatial planning in the circular city, and the circular neighbourhood.

The revised themes and codes revealed during the document analysis were inserted into the framework, and linkages between dimensions were added based on the results of the qualitative analysis. Dominant themes, and key interconnected concepts were identified by comparing and analysing links between dimensions using the 'Analyze' functions of Atlas.ti to summarise key findings and provide a visualisation of core cross-dimensional relationships for the circular neighbourhood. These results were discussed within the Section 7 of this thesis and are visualised within the framework in **Figure 28** below.

The adapted framework presents a summary of the key results related to Spatial Planning for the Circular Neighbourhood. The diagram provides a framework for implementing a CC transition at the scale of the neighbourhood, by holistically addressing all identified dimensions of the research.

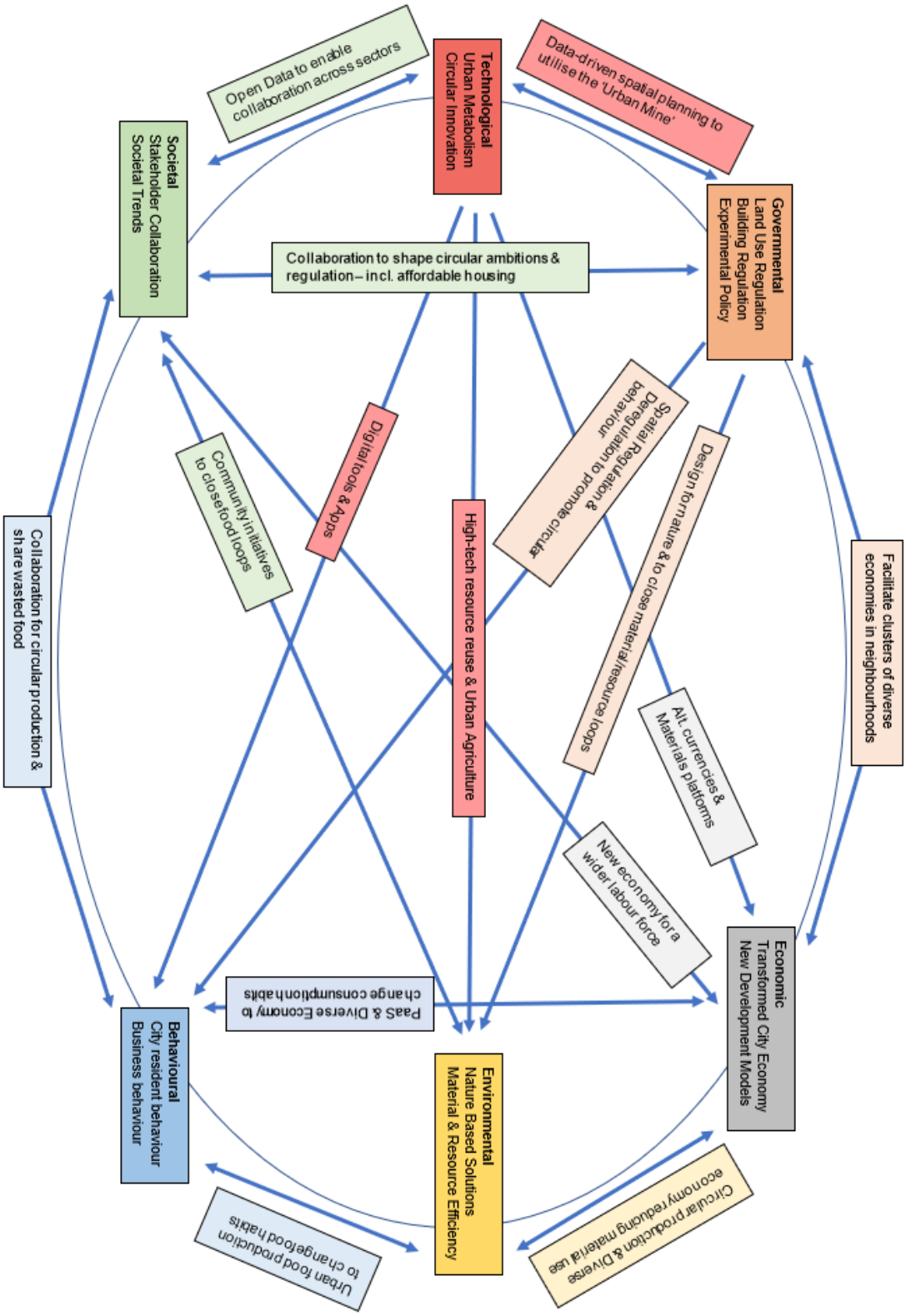


Figure 28 - Adapted Research Framework: Spatial Planning for the Circular Neighbourhood (Source: Author)

9.2 Position in current research

The results of this thesis research provide a closer focus upon the neighbourhood as a unit of the circular city. Whilst the concept of the Circular city is still being established in both research and practice, its implementation at the level of the neighbourhood is currently only understood in experimental approaches. This research provides an analysis of city strategy documents seeking to implement a circular transition in urban environments and provides a framework for the implementation of spatial planning and strategic transformation at the scale of the neighbourhood to aid a transition to the circular city. A growing need for research in the realm of applying circularity in spatial planning at the scale of the neighbourhood was identified within this thesis.

The results of the document analysis and expert interviews are generally consistent with existing literature on the topic of spatial planning for the circular city. Whilst sustainability transitions largely rely on policy making as opposed to implementation (Van de Berghe and Vos 2019, Loorbach et al.2016) a transition to the CC involves a larger integration of 'top-down' and 'bottom-up' approaches to achieve its goals. Current research in spatial planning for circularity identifies the need to transform the physical urban form and land uses towards changing resource consumption patterns, as well as planning for circular economic activities and processes (Williams 2019b, Williams 2020, and Boeri et al.2019). This thesis reflects these current perspectives, and further provider an insight into the multi-dimensional and cross-sectoral links in planning for circularity at the scale of the neighbourhood. In reconciling current conceptualisations of circularity in the city and spatial planning for the neighbourhood, this research distinguishes key considerations for future planning for the city towards a CE transition.

Urban planning at the scale of the neighbourhood has been identified as critical to meeting the goals of sustainable development (Sharifi 2016), due to the ability to apply localised approaches and design principles towards sustainability goals. This research confirms the transformative abilities of the circular neighbourhood and identifies the need for the planning for synergies amongst localised diverse activities, residential land uses, and communal space as a common theme across strategies as a way to close material loops. Previous literature identified the importance of compact growth and mixed uses through higher densities to reduce resource consumption (IRP 2018) but does not acknowledge the complex and integrated approach required to achieve a state of 'circularity' in neighbourhoods. The adapted framework illustrates the need for spatial planning approaches to neighbourhood development to promote resource efficiency in design and functions, promoting circular activities, shaping resident behaviour, with regulations and strategic ambitions both shaped by societal collaboration. Whilst urban green space was not a strong element of the document analysis, expert interviews confirm the need for considering the social importance of green space in the circular neighbourhood as well as its use for promoting social connection through communal urban food growing.

Finally, this research recognizes the role of data and the urban metabolism in spatial planning for circular neighbourhoods which was not previously identified as a focus of quantitative measures of circularity (Petit-Boix and Leipold 2018). The results of this research support the requirement of future regulations and visions to be based on the urban metabolism, with open data access and secondary material platforms being critical to establishing closed loops in construction, business activities, and in future planning of urban spaces. It was also identified as a critical element of shaping city resident behaviour through the use of digital tools.

9.3 Limitations and future research

There were certain limitations with respect to this research given its relation to European city strategies. Generally, given it provides a focused approach towards analysing a small number of city strategy documents and expert interviews, the results provide a specific view towards the topic being within the context of European strategies with an example from North America as an 'out-of-context' point of reference. Nevertheless, the research provided an in-depth analysis of the units of data based on a deep theoretical conceptualisation of the topic as it currently has been explored in research and practice, and subsequent analysis that provides a framework for future spatial planning considerations for neighbourhood development.

A more broadly focused research could potentially be expanded to include other strategies and a wider range of expert opinions to provide a more universal approach to circularity but given the scope of this research and aim to provide a more 'grounded' perspective on circular neighbourhoods – how we live in the circular city, the scope of the research was suitable to answer the research questions.

Future research could consider a broader data set across multiple planning contexts and cultures, with the aim of identifying the most suitable conditions for circular neighbourhood development with respect to land development models or regulatory contexts. Further, this research could inform future practical application of circularity in development plans seeking to stimulate a transition to the CE. The themes identified in the analysis address regulation at both the building scale and larger area scales which are key geographical scales in applying planning controls to shape future built forms and land uses in cities.

9.4 Conclusion & Recommendations

This thesis has studied the interpretation of CC strategies, with the aim of examining neighbourhood development as an element of the circular city, and the implementation of circular strategies and their envisioned impact on the neighbourhood. The research identified current theoretical and conceptual perspectives on the topic of the Circular City, which allowed for the adaptation of an existing research framework to be applied to a document analysis of seven city strategy documents. The document analysis was carried out using a hybrid deductive-inductive approach, first by 'questioning' each strategy against the adapted framework to identify relevant data extracts that relate to the topic of study, and then by coding and analysing the documents for a deeper level of interpretation as well as identification of dominant themes, concepts and outliers amongst the data set. Finally, interviews were carried out as a form of triangulation which supplemented the document analysis and provided a perspective from two experts with experience in developing circular strategies for Municipalities as well as working on 'bottom-up' circular neighbourhood projects. A second round of expert feedback was obtained from one expert who provided additional reflection upon the results of the research and answers to research questions.

The results of this research identify the multi-dimensional aspects of planning for circular neighbourhoods in the city. Whilst generally top-down implementation approaches from

Government were identified as the main ways to facilitate a circular transition in the city, the requirement for cross-sectoral behavioural and societal change was identified as a key element of the circular transition. Spatial planning for the neighbourhood will involve collaborative input to shape circular building and land use regulations, strategic visions for future growth, and experimental development of land. The 'urban mine' and the availability of secondary materials for future development would shape regulations and planning processes, as well as design of future buildings. Additionally, societal collaboration amongst communities, business and government will stimulate and promote a shift in behaviour of residents and companies with the goal of reducing consumption and waste.

Spatial planning is to promote diverse economies within neighbourhoods, including repair and upcycling that are co-located with residential land uses to maximise the closure of material loops. Technological innovations will shape future production and waste recovery processes, as well as enable the trading of circular materials and engagement in diverse circular economies through sharing of data related to the urban metabolism and urban mine amongst society. This research also confirms the constraints of circular strategy implementations at the level of the neighbourhood. Whilst some material loops and economic activities are critical to promote circularity in neighbourhoods to contribute to the broader goal of becoming a circular city, the results identify the limits of fully closing material loops at the scale of the neighbourhood. Urban agriculture and local food production was identified as a dominant theme in the document analysis but its application at the level of the neighbourhood would likely reduce public open space and green spaces. The inclusion of green space and nature in the circular city is critical and could potentially be lost when implementing strategies to promote circularity at the scale of the neighbourhood. The benefit of food production in neighbourhoods for circularity would instead be its community-strengthening connotations as well as awareness raising to promote behavioural change amongst residents with respect to consumption and waste habits.

The concept of the Circular City and its planned implementation aims to reverse the environmental impacts of current resource and material consumption trends within the world's cities. The implementation of CE principles at the level of the city has been explored in existing literature and frameworks to identify and distinguish the CC and its characteristics. Further, bottom-up approaches to CC development include 'living lab' approaches to provide experimental examples of circular principles as applied to small parts of the city.

This research and adapted framework which summarises its key findings allow for recommendations to be made for future professional practice in the realm of spatial planning for circular neighbourhoods. In summary:

- Spatial planning tools are to co-locate land uses to maximise synergies and closing of material loops within neighbourhoods, but must take into consideration that certain loops are not suitable for closing at this local scale.
- 'Regulating for de-regulation' should be approached by designing neighbourhoods to facilitate societal collaboration and to create places for experimental circular approaches in land development and community projects.

- Nature and open space within neighbourhoods should be preserved, with food production to serve a social and communal function rather than seek to meet the consumption needs of local areas.
- Small-scale diverse economies are to be facilitated through planning in neighbourhoods to minimise the distance between consumers and these new circular activities, encouraging their use and changes in resident consumption behaviour.
- The urban metabolism and measure of material flow data can and should inform future spatial planning for circularity. It can guide the implementation of novel material cycling technologies, as well as inform and inspire communities as to the future planning direction of their neighbourhoods.

This thesis has studied CC strategies and their interpretation at the level of the neighbourhood and contributes to existing research by identifying the potential opportunities as well as limitations of circularity when applied to the neighbourhood. It characterises the role of spatial planning for neighbourhoods in the CC, its interconnected elements including societal collaboration and innovative use of data and novel technologies, and its anticipated impacts upon residents within our neighbourhoods. The final adapted research framework provides a concise summary of the research findings and provides a starting point for considerations and future study in spatial planning for circular neighbourhoods.

10. Reflections

Writing this Master's Thesis provided a good opportunity to reflection upon my existing knowledge and learning process when approaching a large research project. Having ventured to complete my Master's degree and academic research after over five years of experience as an Urban Planner in practice, the opportunity to complete a thesis on the topic of the intersection of spatial planning and the Circular Economy presented a welcomed challenge in increasing my knowledge of a new and exciting field (CE) that will undoubtedly shape my practice as a Planner throughout my career.

My first reflection relates to my research process and opportunities to continue my work remotely as an Urban Planner whilst completing my degree, as well as undertaking a six-month internship as part of a circular consultancy during my thesis period. In the first instance, I have learnt from my approach to engaging in both remote work and an internship whilst conducting thesis research. This required a very structured approach to scheduling time in my week but due to unforeseen circumstances and work commitments ultimately resulted in delays in carrying out my research within the timeframe provided. Whilst the research benefited greatly from my experience working within a circular consultancy and inspired an interest in spatial planning for circularity, an earlier acknowledgement of the time requirements of balancing all aspects of my working and learning would have been beneficial and allowed for me to accurately map-out my research plan.

Further, feedback from my Thesis Supervisor was always useful and supportive but I could have taken greater advantage of this support with a more structured approach to my research process – particularly completing smaller sections of my thesis and gathering feedback gradually. I have learnt that my individual working process largely relies on having large blocks of time dedicated to one task, finding it difficult to break-up my week amongst multiple commitments. After finishing my internship, I was able to accelerate my research and writing by only having to balance work commitments and my thesis.

Finally, I have learnt and appreciated the theoretical knowledge and underpinning of my practice as an Urban Planner through academic research related to the topic. It has been invaluable to reflect on planning processes and academic literature in the field after having applied my knowledge in practice. Approaching the study of a new field of the Circular Economy has been engaging and enlightening and I hope to be able to continue to apply and expand my knowledge in this field throughout my career.

11. Appendices

APPENDIX 1 – Interview Guide

Topics to cover:

- Spatial planning for the CC, localised material loops and circular activities shaping the neighbourhood and residents.
- Relationship between the CC and the environment – NBS, use of ecosystem services
- Urban mobility (not so much a focus of strategies)
- Digitisation and tools for implementing, monitoring, and shaping the Circular City
- New economic models in the CC – their place in the neighbourhood

Interview Questions:

Open up with thesis topics, focus on the vision of a circular neighbourhood in the Circular City. Discuss their selection as an expert on the topic of research, experience and what you are hoping to learn from them.

1. *In your experience consulting for cities to prepare CC strategies, what do circular principles at the level of the neighbourhood look like?*
2. *Circular activities and diverse economies are a big part of the CC, how do we plan for those spaces? 'Is scaling up' what we learn from living lab approaches a good start?*
3. *(From the strategies) Designing areas for circularity largely focuses on material loops and synergies but this is mainly focused on industrial symbiosis. What does a symbiosis between houses, small businesses, and the greater city involve?*
4. *Will social economies and new employment opportunities in the CC translate to the neighbourhood? PaaS and new economic models?*
5. *Development models for circular neighbourhoods? How do we incentivise circular principles in the built environment.*
6. *Ecological features of the circular neighbourhood – urban food production and use of public green space/natural water management, what else?*
7. *Changing resident's behaviour as consumers is a large focus of the CC transition – how much of this shift will be individual behaviour and how much business-driven change?*
8. *Overall larger societal transformation is the 'name of the game' – collaboration across sectors, education institutions etc. For neighbourhoods as a unit of the city though, how much scope is there for circularity to grow from these large scale collaborations? Urban mobility is largely ignored but requires top-down implementation.*
9. *What role does technology play in shaping our urban metabolism towards circularity? In the built environment, natural environment, and economic trends.*
10. *Is there a risk of digitisation of the city and neighbourhood under the CC?*

Delphi Round 2:

- Share results across each dimension (key summaries of themes, concepts, outliers, and departure from interview data and document analysis)
- Answers to research questions
- Present adapted research framework and its future application in spatial planning

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