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Master in Urban Climate & Sustainability

Circularity in Cities.

Socio-spatial dimension of the transition
from linear to circular economy as a step towards climate-sensitive urban planning.

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in fulfilment for the requirements of the joint
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In partnership with
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DECLARATION

This dissertation is my own original work and has not been submitted elsewhere in fulfilment of the requirements of this or any other award.

Carlos Soto, 17th of August 2020

ABSTRACT

The contribution of urbanisation to resource consumption, environmental degradation and climate change is a reminder of the need of stronger mitigation and adaptation approaches. This has brought a considerable amount of concepts that have emerged under the umbrella of sustainability, resulting in green, smart, resilient, eco-friendly, low-carbon and more recently "Circular" cities. The aim of this research is to contextualise the alignment of circular economy to socio-spatial issues by leveraging the discussions on the implications of circularity in urban planning and design as a climate-sensitive approach. For that, this dissertation is based on a combination of methods; literature review, interviews and the exploration of Glasgow as a case study amid the "Circular Glasgow" agenda. The spatialisation of variables through GIS techniques is carried and a synthetic view of an urban circularity model is mapped to inform 'where' and 'how' the transition towards a circular city could address aspects such as urban resource management, regeneration, stakeholder's cohesion and wellbeing. This work resulted in the identification of socio-spatial variables/stocks in the city of Glasgow, seen as a multi-variable resource mine with challenges, opportunities and examples not only to pilot but to scale up circular initiatives from the spatial planning perspective. Finally, this thesis contributes to the discussion and invites to further research focused on different aspects that should benefit the understanding of both socio-spatial and climate-sensitive dimensions of the circular economy in cities.

Key words: circular economy, urban planning, socio-spatial dimension, climate-sensitive planning, urban resources, urban metabolism, circular cities, sustainability.

ABSTRACT (Finnish)

Kaupungistumisen vaikutus luonnonvarojen kulutukseen, ympäristön pilaantumiseen ja ilmastonmuutokseen korostaa tarvetta vahvistaa hillintää ja sopeutumista koskevia lähestymistapoja. Tämä on tuonut mukanaan huomattavan määrän kestävän kehityksen alaan kuuluvia käsitteitä joiden avulla on kehitetty vihreitä, älykkäitä, joustavia, ympäristöystävällisiä, vähähiilisiä ja viime aikoina jopa kiertotalouskaupunkeja. Tämän tutkimuksen tarkoituksena on yhdistää kiertotalouden käsitteitä kaupunkien kestävyyden ja suunnittelun kannalta merkityksellisten sosiaalis-spatiaalisten kysymysten kanssa. Työssä hyödynnetään keskusteluja kiertotalouden vaikutuksista kaupunkisuunnitteluun ja muotoiluun ilmastoystävällisenä lähestymistapana. Projekti perustuu erilaisten menetelmien yhdistelmään; kirjallisuuskatsaus, haastattelut ja Glasgow'n tutkiminen tapaustutkimuksena "Circular Glasgow" -ohjelman kautta. Muuttujien tarkastelu GIS-tekniikoiden avulla toteutettiin ja sen pohjalta laadittiin malli kaupunkien muuttumisesta kiertotalouteen. Tavoitteena oli saada tietoa siitä, miten ja millä tavoilla kiertotalouden muutosprosessi voi vahvistaa esimerkiksi kaupunkivarojen hallintaa, uudistamista, sidosryhmien yhteenkuuluvuutta ja hyvinvointia. Tähän liittyy paitsi haasteita, mutta myös useita mahdollisuuksia ja esimerkkejä paitsi hankkeiden pilotoimiseksi, myös kiertotalousaloitteiden skaalaamiseksi aluesuunnittelun näkökulmasta. Lopuksi tämä opinnäytetyö luo muodostaa pohjan keskustelulle ja jatkotutkimukselle sosiaalisista ja tilallisista sekä ilmastoystävällisistä näkökohdista, joita olisi hyödyllistä ymmärtää ja liittää kaupunkien kiertotalouteen ja sen muutoksiin.

ABSTRACT (Spanish)

La contribución de la urbanización al consumo de recursos, la degradación ambiental y el cambio climático demanda de enfoques más sólidos de mitigación y adaptación. Esto ha traído una cantidad considerable de aproximaciones que han surgido bajo el concepto de sostenibilidad urbana, dando cabida a ciudades verdes, inteligentes, resilientes, ecológicas, bajas en carbono y más recientemente, ciudades "circulares". El objetivo de esta investigación es vincular a la economía circular con aspectos socio-espaciales relevantes para la planificación sostenible de ciudades, aprovechando las discusiones sobre las implicaciones de la circularidad en la planificación y el diseño urbano como enfoque sensible al clima. Para ello, este proyecto se basa en una combinación de métodos; revisión de literatura, entrevistas y la exploración de Glasgow como caso de estudio a propósito de la agenda "Circular Glasgow". Para esta investigación se espacializan variables a través de técnicas GIS y se mapea una visión sintética del modelo de circularidad urbana para orientar el 'cómo' y el 'dónde' de la transición hacia una ciudad circular, abordada desde la perspectiva espacial de sus recursos urbanos, la regeneración y la cohesión de actores urbanos. Este trabajo dio como resultado la identificación de stocks socio-espaciales en la ciudad de Glasgow, vista como una mina de recursos multi-variados con desafíos, pero también con oportunidades y prácticas no solo para pilotar sino también para ampliar iniciativas circulares desde la planificación urbana. Finalmente, esta tesis contribuye a la discusión y da ideas para investigación futura con miras a comprender y contextualizar las implicaciones socio-espaciales y climáticas de las ciudades en transición hacia un modelo circular.

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I want to thank my beloved family in Venezuela who supported me from the distance and reminded me daily that they were there for me. Also, to my aunt Xiomara and my uncle Gustavo for always caring, unconditionally.

Out of all my friends I want to mention two of them that supported me in particular means during this master; Dione and Brice, you guys rock.

Kiitos, Thank you, Gracias.

DEDICATION

to my mom, Jacqueline
and my youngest brother Manaure.

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CHAPTER 1

1 INTRODUCTION

1.1 PROBLEM STATEMENT

Climate change has been widely studied. Its relationship with cities and the consequences for both natural and urban environments have been the focus of many research lines worldwide. However, the connections between climate change and the consumption patterns for sustaining both functionally and physically the current urban settings are not always addressed in practical ways that go aligned with the strategies that contemporary cities are implementing or could implement for becoming environmentally friendlier while tackling social and economic issues. Sometimes, the frictions between spatial and economic planning also faces the lack of understanding of the connections between the plethora of concepts, trends and/or approaches that have emerged under the umbrella of sustainability; green, smart, resilient, eco-friendly, low-carbon (Jong et al. 201), and more recently "Circular" cities among others.

The Circular Economy (CE) is a concept that has been gaining ground in the last decade, and as many of the concepts adopted in urban and sustainability studies, it has its origins in industrial ecology and economic planning principles. Its relevance as a trend to shape the climate-sensitive route of organisations and cities lies in its connections to a resource-led system thinking and the ecologic idea of 'feedback' proposed by other concepts related to looping cycles (Geissdoerfer et al. 2016) which suggest a switch in the way material and energy consumption/production are understood as part of living metabolism rather than a liner mechanism (Wolman 1965).

CE represents the latest framework adopted by businesses and the industrial sector to achieve a better alignment with the sustainable development agenda, guiding a transition from a 'consumption to disposal' linear model to a circular one, reducing and rethinking waste (European Investment Bank 2019). From the economic perspective, the circular economy approach represents an ecological trend that promotes an improvement in the means of production and how they are managed, and apart from switching how consumption and waste is perceived linearly, what really seems to drive these ideas to the relevance they have today is the recognition of climate risks as part

of financial risks (Renteria 2019) alongside the rise of new policies upon the local economies.

For the business sector the concept seems logical; closing loops in the supply/delivery chain, cutting down resource consumption and GHG emissions while bringing competitiveness in a market that is progressively moving towards greener approaches and demands. However, as happens with many emerging concepts that sometimes seem to pursue fashionable conceptual ideas with little success in their actual application (Savini 2019), what circularity means for cities aside the economic and waste management perspective is still under exploration (Korhonen et al. 2018a; De vita et al. 2019; Paiho et al. 2020). Could it be a suitable framework to improve the way local authorities execute/manage urban assets, projects, services and facilities in cities? If so, how and where this circularity might happen within the city?

Urban circularity or the idea of "Circular Cities" as coined by some institutions promoting the circular agenda (EMF, Circle Economy, OECD, WEF, World Bank, EIB, EU) is becoming significantly popular in today's academic research and practice, but its socio-spatial dimension is lacking of more contributions (Marin and De Meulder 2018, Prendeville et al. 2018; Ibañez 2019) as cities are primarily social products (Lefebvre 1974) where space is shaped accordingly, and socio-spatial aspects are inherent and dynamic inputs/resources of the urban environment, which availability should not be taken for granted. Albeit there have been many efforts to understand and visualise circular/metabolic models, tools and approaches; most of these studies relate to micro-industrial models or macro-national/regional proposals taking CE as an alternative economic model. Little intervention to bridge the gaps between economic planning and spatial planning at the local scale has been achieved, considering the different components of the urban systems, for the implementation of such a model.

Recently, Glasgow has given some steps towards becoming a circular city; Circular Glasgow is on the table aiming to set an international example as one of the pioneering cities in Europe (alongside Amsterdam, Paris, Brussels, London and more) to bring the circular economy principles to the urban scale. Glasgow has done it so by defining its key sectors for scaling up circularity; such as manufacturing, education and healthcare (Circle Economy 2016). The urban narrative of Glasgow has a deep-rooted collective perception of a city that experienced an urban decay from which it is been recovering since the 80s. In the past, some studies (Maantay 2013, Maantay et al. 2015) have suggested a correlation of health issues in Glasgow to spatial dereliction and certain types of economic activities (Mcdonald et al. 2018). Similarly, the rise of a city

with a considerable amount of disused assets (Glasgow City Heritage Trust 2019) also conditions the implementation of circularity towards a more sustainable agenda.

In that sense, Glasgow as a case study has the potential to serve as an information source to improve the understanding of the linkages between circularity, spatial planning and the engagement of different sectors in a city where urban regeneration remains as a hot topic. Moreover, considering that cities in process of regeneration present opportunities for the transition to greener settings.

1.2 AIM AND OBJECTIVES

The aim of this research is to contextualise the alignment of circular economy to socio-spatial issues relevant to the sustainability and planning of cities, taking Glasgow as a case study amid the "Circular Glasgow" agenda[1], so that the spatialisation of variables can inform 'how' and 'where' the transition towards a circular city could be seen as an opportunity to address some of the challenges that post-industrial settings bring along: urban resource management, regeneration, stakeholder's cohesion and wellbeing. This research project should leverage the discussions on the implications of circularity in urban planning and design as a climate-sensitive approach.

To achieve the aim of this work, the following objectives give direction and milestones in two phases; a conceptual understanding and a local case study; the first representing a review of literature and a tailored benchmarking of local policies and plans that is later used to feed an urban circularity framework from a local perspective.

1.2.1 Specific objectives for the conceptual understanding

- Review and identify the theoretical framework and knowledge needs to cover the gaps of circularity in terms of its application to the urban scale.
- Synthetize and visualise the key elements of a circular city model.

[1] by the time this work has been written, Circular Glasgow is in a stage of about 5 years after it was conceived and has been referred in some literature and report as one of the pioneer cases of circular cities.

1.2.2 Specific objectives for the case study

- Identify local plans, projects and initiatives framed in the sustainability and climate agenda of Glasgow to find their links with circularity.

- Spatialise (when possible) a set of key variables relevant for circularity in Glasgow.

- Explore the strategic potentialities of circularity in Glasgow at the city and the neighbourhood level, from an urban planning/design perspective (urban services, facilities, regeneration, participation).

1.3 RELEVANCE AND MOTIVATION

Because of the dialogue between climate and finance within the circular economy concept, it is probably the first time that economic stakeholders are highly interested in getting involved with environmental issues, which brings a great opportunity for systemic re-structuring processes. The amount of papers about CE and applied circularity have been increasing. But naturally, due to its recent attention, there are several gaps to be covered as the urban scope to which some cities are aiming to remain diffuse; keeping in mind that different from the supranational, national or regional levels, from where guidelines, strategies and policy frameworks emerge, the urban and/or local level deals directly with variables not always included in the former scales, i.e. spatial and social aspects.

The motivation of this thesis topic arose from the experience in Nordic countries we got in contact with during the second semester of MUrCS, where information on resource consumption and the implementation of circular economy principles in the region was given, alongside knowledge sharing opportunities such as the attendance to the World Circular Economy Forum (WCEF) 2019 in Helsinki, Finland which was highly inspiring.

1.4 STRUCTURE OF THE DOCUMENT

As seen in previous sections, this document started with the problem statement, objectives and all the initial rationale of this dissertation, its scope and motivations. From the following chapter onwards, the main body of the document is structured as described:

In the second chapter, the literature review is aimed at contextualising the root issue where this project is inserted; our current climate emergency and the increasing pressure to find suitable approaches to tackle both the present and future conditions of urban settlements in a more sustainable way. Additionally, this chapter offers a state-of-the-art of conceptualisations of the circular economy and its associated concepts to, later on, identify the knowledge gaps that guided the rest of the work.

The third chapter introduces the case study and covers a general view on the premises that are taken into account, placing Glasgow as a city with a relevant background that makes it suitable for its analysis from the circular perspective.

The fourth chapter focuses on the processes carried from the initial literature review until the final results obtained. An emphasis is put on both conceptual and practical approaches with some insights about the use of qualitative methods as well as GIS software for the data processing and mapping. These last tools seen as a mean for achieving some parts of the objectives but without being necessarily the centre of the methodology, as this work is not entirely a GIS-based analysis framework.

The results are presented in the fifth chapter through tables, diagrams, maps and the key highlights of the process. Later, the sixth chapter discusses the implications of these results and their relations with the investigative questions and objectives, as well as the acknowledgement of other limitations and gaps that could be addressed in future research.

Finally, the conclusions compile the main findings and reflections on the opportunities of the work done so far and its relevance for cities like Glasgow. At the end, this document also contains some appendices with information that, because of formatting and structure of the story-telling, were better provided that way.

CHAPTER 2

Three Cs: CLIMATE, CITIES AND CIRCULARITY

2 LITERATURE REVIEW

This chapter offers a review of literature, reports and documents relevant to the problem and the aim of this work; starting with a brief on the general context in which this thesis is developed, followed by introducing key concepts, theories and the background research that support this work alongside recent findings on circularity in cities, with an emphasis on how urban variables for the application of the circular economy are approached. At the end of this chapter the knowledge gaps and major research questions that guided the dissertation are presented.

2.1 AN INCREASINLY URBAN WORLD

Most of the ideas discussed in academic articles, essays and reports on resource management, and population growth, bring ideas and concerns that date back to the 18th century and the times of industrial revolution, later stressed by following research consortia from the 20th century[2]. These concerns are still gaining relevance in modern times, given the now visible consequences of urbanisation and its impact on the environment.

Further deterioration of natural assets, increasing problems associated to the consumption patterns of humanity along with emerging social issues and technological advances, are among the major transformations that are shaping our present and near future.

[2] An enquiry into the Nature and Causes of the Wealth of Nations (Smith, 1776), An Essay on the Principle of Population (Malthus, 1798), The Population Bomb (Ehrlich, 1968), The Limits of Growth (Club of Rome, 1972), Our Common Future (WCED, 1987), and so on.

We live in a world increasingly urban; 3 million people are moving to urban areas every week (UN-Habitat 2009) and even though cities occupy about 2% of sland area, it is in urban setting where half of the world population lives, with figures surrounding 75% of urban population in Europe and about 80% in America (UN-Department of Economic and Social Affairs 2018) expected to reach up to 68% on a global scale, passing from 4.2 billion (2018) to 6.7 billion people by 2050, meaning that up to 85% of people will live in cities in more developed regions and 64% in less developed regions, as seen in the Figure 1 (ibid).

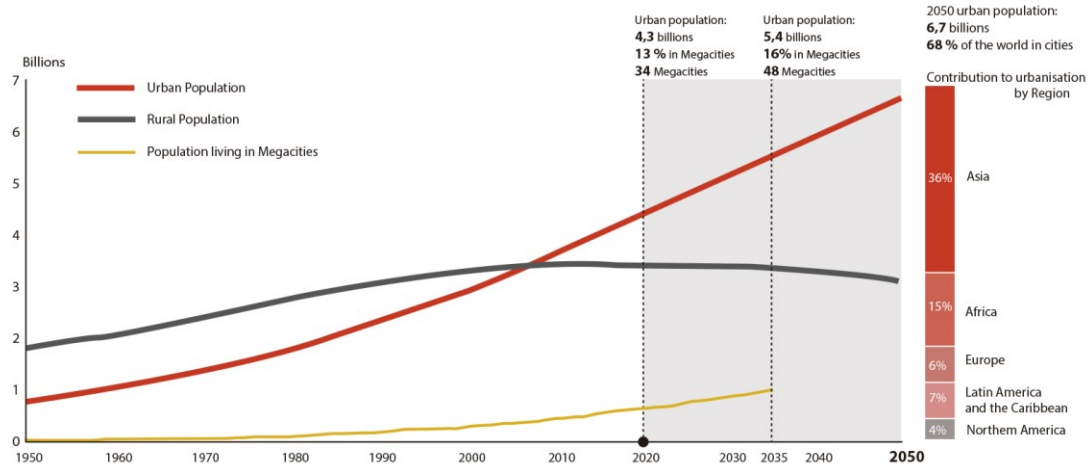


Figure 1. ***Global growth in urban population 1950-2050 and contribution per region.***
Adapted from United Nations Department of Economic and Social Affairs, World Urbanization Prospects: The 2018 Revision-Population.

It is well known that cities generate about 85% of global GDP, while consuming 75% of global resources, emitting around the same percentage of global energy-related greenhouse gas emissions (UN Habitat 2019). Circa 50% of all waste is generated in cities and that number is expected to reach 70% over the next 30 years (Enel, 2019) unless radical reversal actions are put in force.

In this context, research endeavours aim to determine whether the current paradigms and approaches to tackle direct and indirect consequences of urbanisation in the environment, can be adapted to respond to both accumulated and emerging issues. In the following sections a review of different reports, articles and ongoing research projects that related to this matter is provided to get a general picture of the state-of-the-art of the application of the circular economy in cities as an alternative model to tackle resource and climate issues.

2.2 CITIES AS THE EPICENTER OF CLIMATE ACTION

As the world population becomes predominantly urban, cities are significant contributors to climate change and environmental degradation, but are also one the most prone-areas at the same time; given the fact that 90% of urban areas are situated nearby coastal zones (Figure 2), putting most of them at risk of flooding from rising sea levels and powerful storms (C40CITIES 2019). The Report *Adapt Now: A Global Call for Leadership on Climate Resilience* (Global Commission on Adaptation 2019) found that investing US$1.8 trillion in climate adaptation can generate US$7.1 trillion in total benefits in one decade from 2020, focusing on key areas like early warning systems, climate-resilient infrastructure, improved dryland agriculture, mangrove protection and resilient water resources. The reports call for changes in (1) understanding, (2) planning and (3) financing across seven interlocking systems within cities and infrastructure (Ibid).

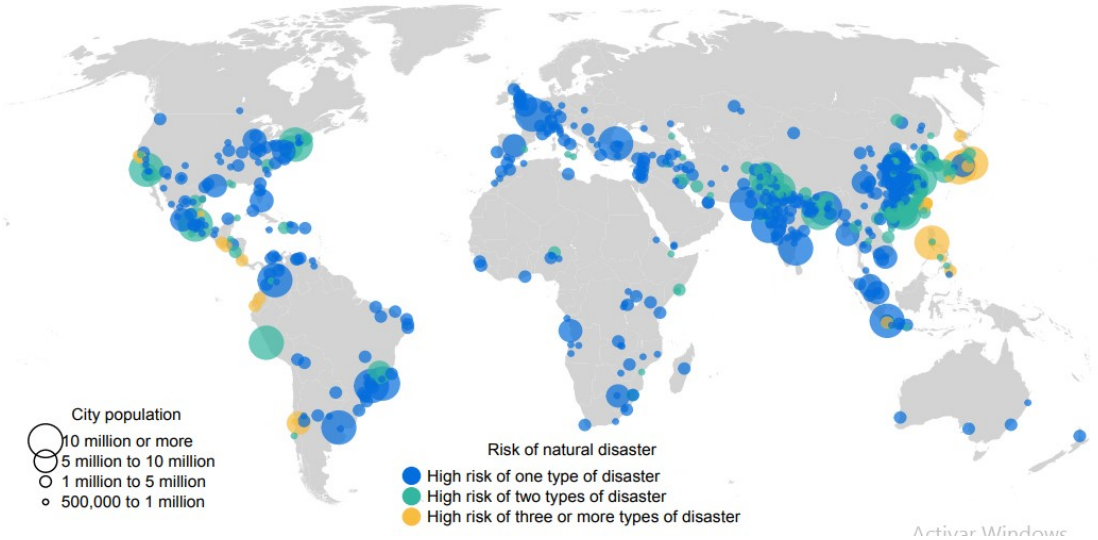


Figure 2. ***Cities' risk of exposure to natural disasters per rank of exposure and population size.***
Source: as presented by United Nations Department of Economic and Social Affairs, World Urbanisation Prospects: The 2018 Data booklet. (www.un.org)

There is global interest and commitment to join the climate-sensitive race, yet only 105 out of 861 cities (12%) that disclosed to CDP[3] in 2019 are rated 'A' for their climate leadership and action to cut emissions, which is indeed an increment from the 7% registered in 2018 (CDP 2019). Although there are many context-specific aspects that affect the availability of data in this reporting systems, these figures are highly affected by different realities in terms of resources and the local economies of the majority of

[3] Disclose Insight for Action (CDP), has been compiling data and from cities and companies all over to track and promote sustainable actions and provide open data though their online platform https://data.cdp.net/

cities in developing countries. According to the Collaborating Centre on Sustainable Consumption and Production (CSCP); cities in developing countries face multiple challenges because of the rapid increase in their urban population, with limited access to social services, burgeoning municipal waste generation, inefficient infrastructures and air pollution, whereas in developed countries cities aim at reducing resource and energy requirements, climate change, tackling shrinking populations, decreasing labour conditions, and withdrawal of the welfare state (Future Earth KAN SSCP Working Group 2018).

The fight against climate change and environmental pollution was reinforced during the 21st session of the COP to the United Nations Framework Convention on Climate Change (UNFCCC) held in Paris in December 2015, by demanding cities to become resilient to climate change by increasing energy and resource efficiency, solve the existing social imbalances, and improve human wellbeing while sustaining population growth. Nevertheless, 75% of infrastructure required to support the 2050s scenario is not yet in place today (Global Infrastructure Basel Foundation 2014) and this will demand a significant amount of resources, not only financially but also in terms of materials and other raw resources.
Public institutions have aligned efforts during the last decade; whether setting taxes and other low-carbon financial incentives (London), equipping the waterfronts to add protection against the increased flooding and storms (The Hague), building light rails and alternative modes of transportation (Calgary) or fixing water leaks to tackle droughts (Taipei), city authorities have taken the lead to face the climate emergency in different ways (Forbes 2019).

Some researchers have connected the way policies and frameworks - designed to tackle climate change and other environmental problems - could directly or indirectly draw a path towards the circular economy. Lausselet et al. (2017) highlighted how energy transitions can be merged with other issues such as waste management in order to cut carbon emissions. Wysokinska (2016) analysed the different activities and tools designed from the European Union (EU) towards environmental policies aiming to low carbon economy technologies, managing limited natural resources, environmentally friendly transport package, biodiversity and others initiatives framed in the LIFE programme to work strategies preventing climate change as potential builders of the circular economy. Similarly, Behrens (2016) considers the direct relationship between the quantity of raw materials used in industrial processes and GHG emissions as a condition that entails a required focus on material reduction as a root cause, thus

translating CE into a key vision for climate-sensitive policy. Moreover, in a recent case study based in Brussels, Christis et al. (2019) showed how city-level primary material footprint (MF) and carbon footprint (CF) of households can be quantified to plan CE strategies action plans on consumption domains that improve resource efficiency and reduce GHGe, hence enabling climate change mitigation at the urban scale.

In terms of the urban scale, there are many nuances that remain diffuse in academic research, but this scale has gained momentum in practice in the last decade. The climate and environment action plans that cities like Barcelona 2018-2030, Copenhagen 2017-2025, Paris 2018-2030, Stockholm 2016-2040 have put in force, include among their city-level strategies the circular economy as a mean to manage resources, waste and emissions. Similarly, in China, CE has become an inherent part of their development model to overcome the high levels of pollution, specially accentuated shortly after the country joined the WTO in 2001 (ING, 2016). These academic and institutional examples acknowledge that climate action in cities is merging or connecting with CE initiatives.

2.3 CIRCULAR ECONOMY: AN EVOLVING CONCEPT

The traditional economy, also referred to as linear economy, follows a "Take – Make – waste" resource flow, this manner of economic development has ruled and increased since industrial revolution. During/after industrialisation, many reports on sustainability have aimed to rise environmental and consumption awareness. But more recent evidences and trends towards an environmental crisis are the baseline for contemporary scientific research papers on the required transition into more efficient ways of consumption and production. The Circular Economy is one of the most popular emerging concepts in the last decade.

Few times in history the financial and business world has shown such interest in climate and environmental issues, but due to the current changes in supranational, national, regional and local policies and regulations in terms of pollution, emissions and their associated costs (Renteria 2019) which are directly or indirectly enforcing climate action across all sectors; firms that do not fulfil certain criteria must bear the sanctions imposed, increasing their costs (Ibid) and this has given momentum.

Jointly with the circular economy, different initiatives have taken place in the last decade include, and are not limited to; the implementation of carbon tax, tradable instruments, green bonds among other ideas towards a greener economy. All of these based on the fact that climate risks will affect not only the availability of resources but also the projection of profit for the economic engine of cities and nations (ICMA 2018).

By definition, the circular economy (CE) concept is rooted to the idea of looping systems, where flows of resources and materials can be seen through the lens of a living metabolism (Ellen Macarthur Foundation, 2013). It is suggested by different papers that all contemporary ideas related to this thinking were first inspired by Boulding's essay; *Economics of the coming spaceship Earth* (1966) (Kirchherr et al. 2017; Korhonen et al. 2018b). In some academic papers the raise of the CE concept is attributed to Pearce and Turner (1990), two British environmental economists (Su et al. 2013). Some others add that CE has European roots, but its recent evolution as a model started after the enforcement of related regulatory controls in Japan followed by the own definition of standards implemented in China leading to their Circular Economy Promotion Law (2009) (Wang et al. 2018).

Regardless its origins, Geissdoerfer et al. (2016) points out that contemporary definitions of CE, and its practical applications, incorporate different features and contributions from a variety of previous ideas and disciplines such as industrial ecology, regenerative design and cradle to cradle, concluding that the similarities or feedbacks between CE and sustainability - as a paradigm - are complex to identify through scientific papers only, so that contributions also arise from grey documents and reports (Ibid)[4] from the industry, considering that scientific research moves slower than the practitioners' community (Korhonen at al. 2018a; 2018b).

In an exhaustive study of 114 definitions, Kirchherr et al. (2017) founds that the circular economy has many nuances. The study is based on previous research[5] where over 150 articles were summarised to conduct comparisons between the CE and its relation with other contemporary concepts such as sustainable development, environmental sciences, circular business models, sustainable business among others. The results showed that, by definition, the most common conceptualisations of CE focus on

[4] Geissdoerfer et al. (2016) identify connections of CE with Laws of ecology (Commoner, 1971), Industrial ecology (Graedel and Allenby, 1995), Regenerative design (Lyle, 1994), Cradle-to-cradle (McDonough and Braungart, 2002), Biomimicry (Benyus, 2002), Looped and performance economy (Stahel, 2010), and the Blue economy (Pauli, 2010).

[5] Ghisellini et al. (2016); Lieder and Rashid (2016); Blomsma and Brennan (2017); Sauvé et al. (2016); Murray et al. (2017); Geissdoerfer et al. (2017); Lewandowski (2016) as cited by Kirchherr et al (2017)

recycling and reusing more than other Rs, being recovery and reduction less prominent, which is later associated to the properties of existing policies, as they favour or find more feasible the former two Rs (Kirchherr et al. 2017). Also, the authors highlight that after 2002 a systemic vision has arisen, evidenced in definitions calling for actions that differentiate macro from meso levels. On the other hand, only 12% of the definitions analysed in the cited study showed an explicit link with sustainable development, entailing one or two of the three dimensions. Finally the study claims to confirm that the 'CE concept largely neglects social equity'[6] (Ibid 2017, p. 227) and emphasises a necessity to incorporate social equity as a design and research variable. This aspect also addressed by Korhonen et al. (2018b) in their analysis on the limitations of the concept, after which a proposal is made; exploring the potential contributions that CE could bring to the triple bottom line, especially in terms of the so-called sharing economies.

After the assessment carried by Kirchherr et al. (2017), their report concludes the circular economy is a young field and the most popular definition appears to be the one coined by the Ellen MacArthur Foundation (2013, p. 7, *emphasis added in bolds*) which defined it as:

> An **industrial system** that is **restorative or regenerative** by intention and design. It replaces the 'end-of-life' concept with **restoration**, shifts towards the **use of renewable energy**, **eliminates the use of** toxic chemicals, which impair reuse, and aims for the **elimination of waste** through the superior design of materials, products, systems, and, within this, **business models**.

The paper suggests a definition that encompasses all other CE definitions:

> An **economic system** that replaces the 'end-of-life' concept with **reducing, alternatively reusing, recycling and recovering materials** in production/distribution and consumption processes. **It operates 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**, thus simultaneously creating **environmental quality, economic prosperity and social equity**, to the benefit of current and **future generations**. It is enabled by novel **business models and responsible consumers** (Kirchherr et al. 2017, p. 229. *Emphasis added in bolds*).

[6] This is a key conceptual statement, since the lack of vehemence on both the R associated to Recover and the social scope, as well as the micro level of systems in the definitions of CE are of special interest when translating the concept to the urban scale, specifically to the local level which is part of the focus of this thesis.

Yet, apart from the discussions on the definition, some authors think the existing CE work is mainly done on technical levels of the flows of materials and energy in production/consumption systems (metrics, tools, instruments). Therefore, the values and socio-cultural structures underlying the potential of CE remain largely unexplored (korhonen et al. 2018a) as well as their application at the city level.

In most recent publications by the Ellen MacArthur Foundation and Materials Economics (2019, p. 18)[7] the CE is placed as the element that 'completes the picture of what is required to tackle the climate crisis' by offering an approach that transforms the way things are designed and used. The report suggests that 45% of total global emissions arise from the management of land, buildings, design of products and other goods and assets we use daily, and from those, almost half of the reductions can be achieved via the circular economy, whereas the other half is shared between carbon capture and storage, diet shift, among other strategies and proposals (Ibid 2019).

In the same report, an updated definition for a circular economy shows an evolution that somehow incorporates the lacking elements identified before by Kirchherr et al. (2017). It is defined CE as follows:

> The circular economy is a **systems-level** approach to **economic development designed to benefit businesses, society, and the environment**. A circular economy aims to decouple economic growth from the **consumption of finite resources and build economic, natural, and social capital**. Underpinned by a transition towards **renewable energy sources** and increasing use of **renewable materials**, the concept recognises the importance of the economy **working effectively at all scales**. This means it features active **participation and collaboration between businesses both small and large, and from countries and cities to local communities and the people within them.** Such a distributed, diverse, and inclusive economy will be better placed to **create and share the benefits** of a circular economy. (Ellen MacArthur Foundation 2019, p 19. *Emphasis added in bolds*)

[7] By the time this literature review has been done, the newest publication is the report titled: Completing the Picture: How the circular economy tackles climate change. Published on the 26th of September 2019 on their official website.

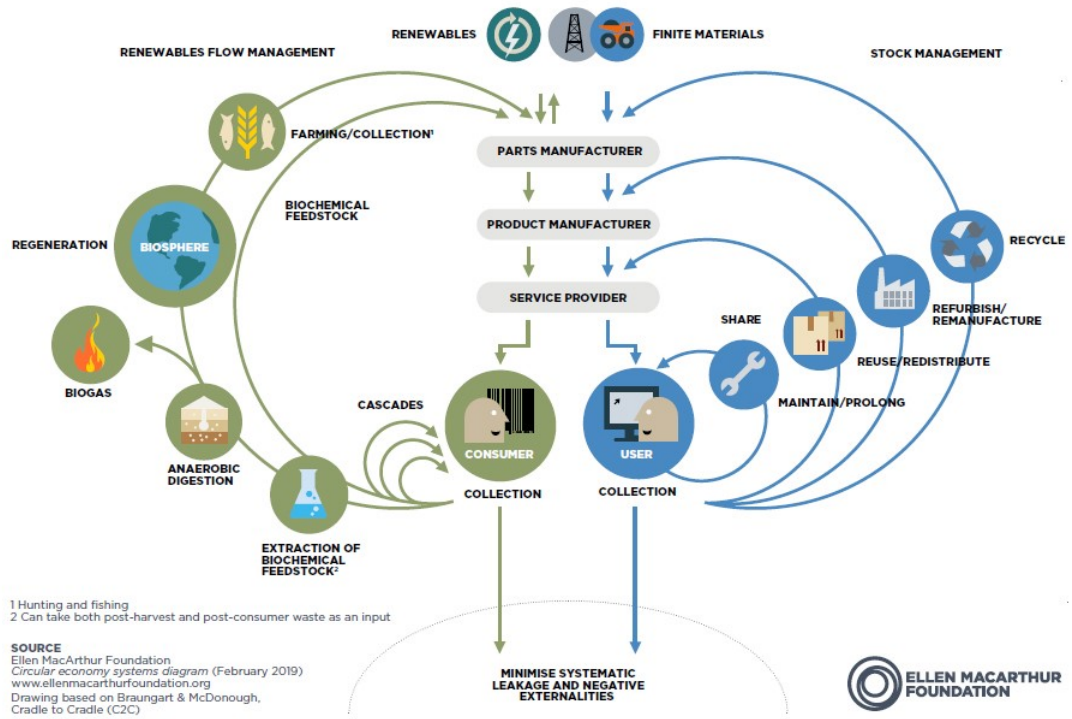


Figure 3. ***Circular Economy System Diagram.***
Source: Ellen McArthur Foundation (2019)

The definition keeps evolving as now integrates a multiplicity of scales and systems (Figure 4), and a closer notion of sustainable development, collaboration and shared benefits across all levels involved at least on paper, yet to be expressed in practice. One of the most relevant characteristics of this recent definition is the explicit inclusion of the city, community and people's levels. This last might be explained by the increasing interest from institutions to implement circular economy oriented agendas at the urban scale. Discussions on the actual application of the concept are still open in academia, industry and governmental institutions.

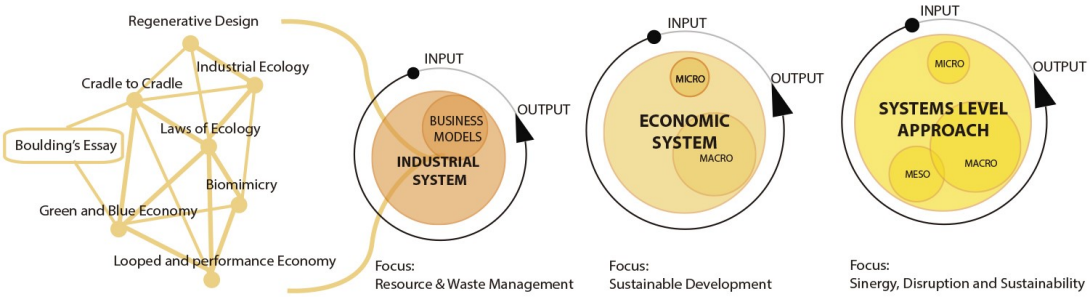


Figure 4. ***Simplified diagram of the evolving definition of Circular Economy.***
Own edition, based on reviewed literature and previously quoted concepts.

2.4 CIRCULARITY IN CITIES AND THE UMBRELLA OF SUSTAINABILITY

Sustainability is a concept that is well known in the academic world, its origins and theoretical evolution have been widely studied. It is, at present, well accepted beyond academia to define frameworks and approaches in businesses, economic plans, city planning, architecture and many other fields. Its more popular definition is based on the economic, environmental and social dimensions of growth and use of resources to satisfy needs in the present, without compromising the future generations (Bruntland 1987).

In city planning, several branches of sustainable thinking have been merged to combine the "People, Profit, Planet" framework to other variables or Ps relevant for cities, such as 'Policies' and the scale of 'Place' (OECD 2019), keeping in mind that urban problems are complex and with variability of outcomes. As acknowledged in the work of Du Plessis (2009) there has been an advance in the city planning field to become more holistic, recognising the complexity of urban systems.

2.4.1 Sets and subsets of sustainable cities

The formation of a Sustainable Urban Development Paradigm (SUDP) has followed the sustainability sciences (Shemirani et al. 2013) and it has represented a theoretical umbrella under which other contemporary trends of urban development have tailed their paths, bringing up not only the comprehensive concept of 'sustainable cities' that at some extent contains the subset of green, eco, low carbon, liveable cities. But also, resilient cities with specialised aims to adaptation and emergency management (World Bank 2019); knowledge cities and smart cities as other important set of concepts involving technological solutions that have become relevant after 2012, as the recurrence in the academic discourse has evidenced, and other emerging concepts which use - regardless of the interconnections - is not interchangeable (Jong et al. 2015).

The connections between the concepts of sustainability and the circular economy are getting indirectly amalgamated to climate action in cities, as many institutions and local authorities are in the race for 'circularity' along with the sustainable and climate action in cities, addressing a combination of scattered efforts aiming to tackle similar issues. Most contemporary approaches seem to be guided towards the bio-ecological systems and the support of grassroots initiatives (O'Donnell et al. 2019; Bristow & Mohareb 2019; Amenta et al. 2019)

2.4.2 *Urban metabolism: system thinking for the urban environment.*

The urban metabolism (UM) approach started as a systemic vision to understand urban services when Wolman (1965) analysed water demands/disposals and air quality for a hypothetical city of 1 million residents, concluding that these services would always be conditioned to the regular dynamics of growth and consumption. From that time, UM became an essential concept in understanding resource consumption in the urban environment as a living organism.

Decades ago, in a case study on weak and strong sustainability measures for cities, Moffatt (1999) described a strong sustainable cities model that was close to what is now promoted/practiced as the circular metabolism in cities, with materials being reused, repaired, and recycled; recognizing the limits of inputs and the capacity of outputs (Assefa 2019). Moreover, the understanding of urban metabolism through Material Flow Assessments (Bahers et al. 2018) widely used in industrial ecology, and Life Cycle approaches (Maranghi et al. 2020; Butt et al. 2020; Petit Boix et al. 2017. Assefa 2019) are discussed among proposals of sustainable urban environments.

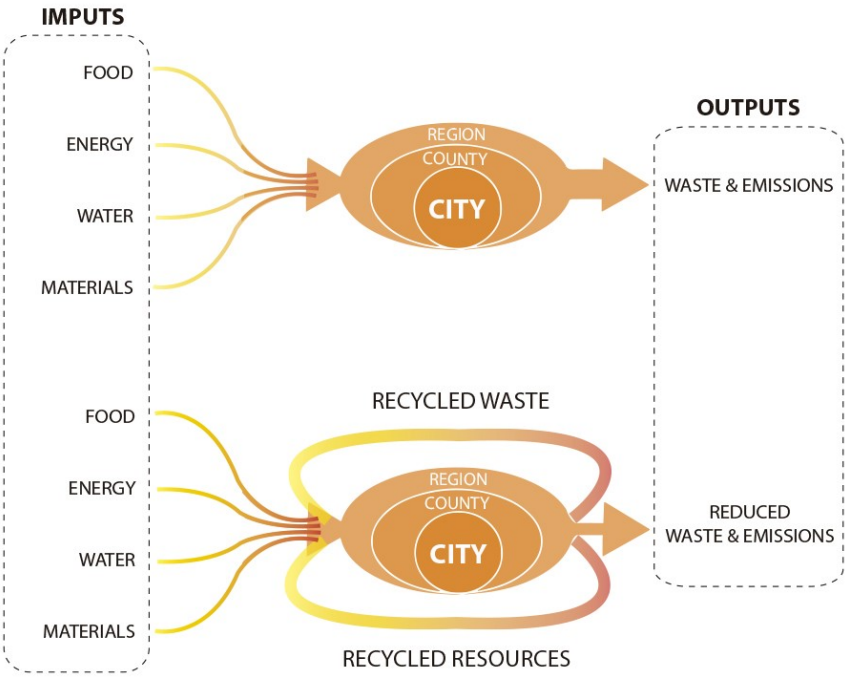


Figure 5. ***Urban Metabolism (Linear and Circular).***
Adapted from the ideas of Novotny et al. (2010) and Bahers et al. (2018).

Although first criticized for simplifying urban flows without considering the dynamics of infrastructures, flows of information and decision-making processes, urban metabolism definitions have been benefited from the contribution of recent academic work addressing this demands; linking social processes to temporal and even spatial attributes of flows, materials and services (Dijst et al. 2018), and the application of UM to comprehend the relations between buildings and energy use, local food production, waste/resource management in cities, climate comfort, energy fluxes and urban forms (Palme & Salvati 2019). One popular definition is that UM is 'the total sum of the technical and socioeconomic processes that occur in cities, resulting in growth, production of energy and elimination of waste.' (Kennedy et al., 2007, p.44, as cited in Prendeville et al. 2018). This means that urban metabolism is a descriptive concept, not a prescriptive one, such as the circular economy or circular metabolism.

Understanding the organic character of flows as living and dynamic processes, has led to the conceptualisation of frameworks based on city resilience, seen urban systems as part of an Urban 'Immune System' (Bristow & Mohareb 2019). On the other hand, some papers recognise missing links between UM analyses and the execution of real-world design solutions for better integration of urban planning disciplines and urban ecology (Perrotti 2020). Thus, while the theoretical potential of seeing cities through the lens of urban metabolism to support urban design, planning and policy development is supported in scientific literature, its practical implementation is so far limited to conceptualisations in the context of resource efficiency in cities (Musango et al. 2017).

Regarding the spatial dimension of UM, there are still many gaps. Thomson & Newman (2018) determined that different parts of cities have different urban fabrics, hereby different metabolism associated to its land use and transportation settings. To do so, the authors characterised three types of urban fabric -walking city, transit city, automobile city- with its land uses and general building forms. They concluded that individual optimisation of buildings can help to improve metabolism, but addressing neighbourhood or precinct scale helps to enhance community services, highlighting the potential of the precinct scale to pilot further actions that could be turned into policies and cumulative works towards a regenerative city. This localised approach is highly relevant and can be reinforced with synergetic views on small system dynamics, as the one proposed by the Transition Towns movement, described in the next section.

2.4.3 *Transition towns: social innovation and local practice*

Because of the geographic and thematic relations with the object and subject of study of this thesis, the Transition Towns (TT) movement is a key reference as a previous initiative that promotes social-spatial action while addressing 'glocal' issues (Transition Network 2016). It has its origins in the UK back in 2005 - way before the circular economy gained the space it has in the current urban scene – with Totnes being the first town that partook in the initiative, eventually becoming the hub of the Transitions Towns Network later extended throughout the UK with 324 initiatives, and other 31 countries forming 421 communities and 959 initiatives worldwide[8]. This movement is based on local initiatives towards community resilience in response to environmental, social, economic and other challenges. It is rooted in a design method known as permaculture, which takes inspiration from ways in which natural systems self-organise for resilience and productivity (sort of a metabolic approach). Initially the TT was a local response to the oil, the climatic and the economic instability (Transition Network 2016).

Scotland has operated its own national coordination structure since 2010 and it is a member of the Scottish Communities and Climate Action Network (SCCAN) since 2018, which accounts 7 transition initiatives, like Edinburgh, Glasgow and Stirling.

Figure 6. ***Transition initiatives worldwide.***
Source: www.transitionnetwork.org

Recent papers have compared the community-led method (bottom-up approaches) used in Transition Towns initiatives, to commonly top-bottom strategic planning (Burbridge 2019) by analysing participatory workshops to draw conclusions on how TT

[8] Based on the number shown on the websites' maps and database.

are implemented versus the general big picture to which it aims. Other studies have addressed the disruptive social structures that are behind transition movements and how the so-called 'Just transition' and green capitalism dialogues or intersect them when applying initiatives to foster local food systems, small scale energy economies, sustainable communities and alternative housing (Star 2020).

Before the European parliament's support to the circular economy, the Transition Towns Movement had different kind of local projects that were unintendedly aligned with the circular economy principles. The Totnes Renewable Energy Society was formed in 2007 by residents concerned about climate change and since then they have crowdfunded, through a green finance model, different local energy production projects giving interest payment to its members (TRESOC 2019). Similarly, the local-run organisation Transition Homes Community Land Trust owns and manages land and other assets for the benefit of the community (TTT 2020) and more recently in 2017 Totnes formed a new community led group with a focus on reducing waste and recovering wasted resources (Ibid).

2.4.4 Circular cities: are we there yet?

Cities are dynamic, complex and multivariate systems. Thus, urban planning challenges are diverse and sometimes wicked (Rittle & Webber 1973 p. 160, as cited in Du Plessis 2009). The concept of circularity is now considered as an alternative to be applied in the development of policies addressing urban management issues in terms of the reorganisation of services, especially those related to waste management in cities and regions (Savini 2019). Because of its potentialities, the idea of circular cities has many supporters in the industry and academia, but others question its business-oriented narrative and fear that, if not tailored, it can be 'the latest in a host of urban sustainability trends, that have arguably failed' (Prendeville et al. 2018, p. 3) or 'the latest and most sophisticated version of the 'sustainable' fetishized commodity' (Valenzuela & Böhm, 2017, p. 28, as cited in Savini 2019) as part of emerging debates on circularity as a contemporary urban agenda. Whether the CE takes further or not the necessary changes instead of renaming the same problems with new labels to set an 'imaginary solution' to the contradictions, tensions, and limitations of current policies and practices is a matter that will depend on how political and economic agendas can meet the socio-spatial needs of cities in line with proper governance scenarios (Kębłowski et al. 2020).

Prendeville et al. (2018) studied six cities in transition to CE practice, the study covers a review of documents and literature alongside interviews, concluding that although there are common approaches being used to implement circular city practices, there is still a lack of direction on what a circular city should be. The study also suggests that circularity might overlap with some sustainable and smart cities strategies.

In that sense, while some cities are self-proclaiming to be circular, some others might be spontaneously implementing unlabelled circular initiatives, because policies and practice are moving forward regardless of the theoretical gaps and discussion in academia. Thus, it is common to find emerging definitions and frameworks for circular cities by independent organisations in both public and private sector.

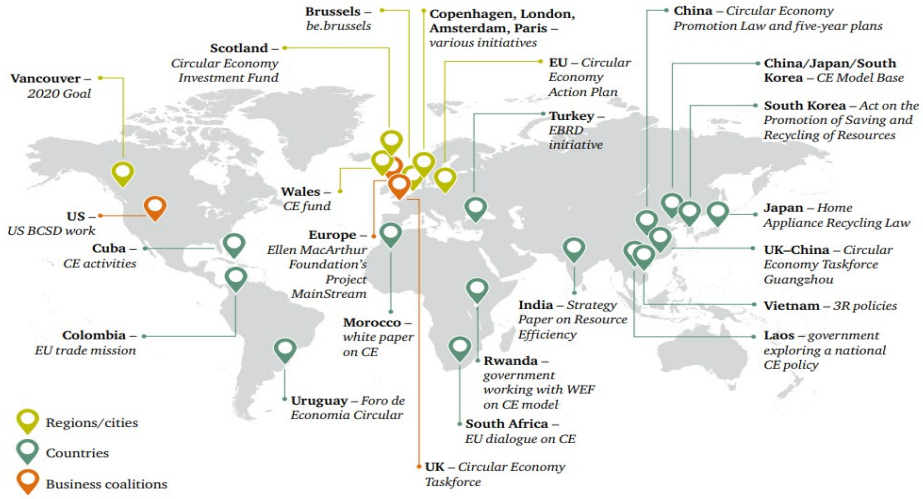


Figure 7. ***Circular Economy in Cities and Regions.***
Source: Preston & Lehne 2017, as cited in WEF 2018.

One of the main bodies or actors promoting the movement towards circularity is the Ellen MacArthur Foundation (EMF) which launched a global *Circular Cities Network* in 2016 and envisions a circular city through 5 key characteristics; (1) a built environment designed in a modular and flexible manner, (2) energy systems that are resilient, efficient and renewable, (3) urban mobility systems that are accessible, affordable, clean and efficient, (4) urban bio-economy where nutrients will be returned to the soil and (5) production systems that encourage local value loops and minimise waste. Recognising among the enablers, the proximity between users and producers, the effectiveness of market scales, the ability of city governments to shape urban planning/policies and the digital evolution (EMF 2017).

In a report by the World Economic Forum (2018), a Circular City is defined based on the Ellen MacArthur Foundation's proposal:

> a circular city embeds the principles of a circular economy across all of its functions, establishing an **urban system that is regenerative and restorative by design**. In such a city, the idea of **waste is eliminated**, with assets kept at their **highest levels of utility at all time**s and the use of **digital technologies** a vital process enabler. A circular city aims to generate **prosperity and economic resilience for itself and its citizens**, while decoupling value creation from the consumption of finite resources (WCF 2018, p 10).

From the academic point of view, Marin & De Meulder (2018) addressed the question of how to define the circularity in cities by comparing four circular urban imaginaries. The study brings a set of conclusions highlighting that multiple frames are required to address the complexity of circularity in cities; Governance is both implicit and explicit in spatial circularity and there is a direct influence from the leading disciplinary field of circular agendas, which affects how drivers are addressed (i.e. if the leading organisation or stakeholder is an economic actor, or a design/planning actor, this will condition the scope and outcome of the initiatives)this is why circularity cannot be realised without multi-agency intervention. However, design is a pivotal transdisciplinary field to achieve multi-scale and place-specific objectives (Marin & De Meulder 2018).

On a different note, by taking examples from the industry, Williams (2019a) proposes an alternative for the understanding of circular cities, based on the RESOLVE framework by the EMF[9]. Her paper makes a critical appraisal on how the principles of the circular economy need to be adapted before being applied to urban areas. This paper is part of the work done in the Circular Cities Hub at University College of London, a group that has conducted workshop-based research on the conceptualisation, barriers and challenges to looping actions in circular cities (Williams 2019b). All these studies (Marin & De Meulder 2018; Williams 2019a, Williams 2019b) offer an insightful overview towards the characterisation of the circular economy for urban areas, but do not propose a comprehensive and specific definition or visualisation for a circular city. Something that is partially covered by Paiho et al. (2020) which summarised some academic findings defining a circular city as one:

> (…) based on closing, slowing and narrowing the resource loops as far as possible after the potential for conservation, efficiency improvements, resource sharing, privatization and

[9] The RESOLVE framework is based on 6 strategic principles or actions that are aligned to what a closing-loop economy should aim in order to become circular. RE stands for regeneration which along with Share, Optimise, Loop, Virtualise and Exchange set a starting conceptual point to start developing circular action.

> virtualisation has been exhausted, with remaining needs for fresh material and energy being covered as far as possible based on local production using renewable natural resources. (p, 16).

The spatialisation of circularity in cities is still being discussed. In the past, projects like CirCUSE (2010-2013) joined efforts to produce a compendium towards a circular flow of land, aiming to reduce the urbanisation of the landscape, turning the 'take-make-waste' linear approach into a 'avoid-recycle-compensate' kind of development for regional land management. In the ongoing EU funded project CLIC, researchers are analysing circular models for levering cultural heritage and reuse in cities, and they intend to come up with answers for some of the gaps on what circular cities are, how urban planning can help to implement them and what role CE plays in regeneration. The first phase of CLIC focused on the diversity of territorial contexts, stressing that copy-pasting solutions is not effective (De vita et al. 2019). Hence, every city needs to start by looking at their own challenges and small-experimental projects to later scale them up into policies for achieving urban circularity through actions tackling spatial planning issues such as land consumption reduction and the reuse and optimisation of built assets (Giorgi et al. 2020), by considering as well the repurposing of functions and the re-creation of values to activate durable and self-maintained regeneration (De vita et al. 2019). Similarly, the project REPAiR, also an EU-funded project, aims to build understanding on how circular economy translates to urban governance and territories by exploring methods (Obersteg et al. 2019: Amenta et al. 2019), tools and geolocation technologies (Arciniegas et al. 2019) to reinforce the urban application of circular solutions in cities.

2.4.5 A matter of scales and systems

In a meeting of the *Association of European Schools of Planning* (AESOP) some researchers pointed out that waste management and resource efficiency were still the common goal of the circular economy, and this has seldom been applied to the urban scale (Cheng & Chang 2018). This highlights the relevance of the latest consortium-led projects that have been emerging from supranational-funded initiatives, as referred before; CLIC, REPAiR, CirCUSE, etc.

Coenen et al. (2012) state that, in the past, the literature on transitions towards sustainable socio-technical systems has contributed considerably in understanding complex and multi-dimensional shifts. However, transition analyses have often

neglected where transitions take place, and the spatial configurations and dynamics of the networks within which transitions develop.

Cheng & Chang (2018) consider that a model approaching the consumption dynamics and the distribution of inputs/outputs in manageable if defined in scales, such as '*Townships*', to analyse ecological systems and inform a comprehensive and scaled urban metabolism. Recently, Bahers et al. (2018) found that distinguishing between zones of influence within megacities, rural zones and intermediate cities is necessary to understand the flow of materials in urban areas. Moreover, Bristow & Mohareb (2019) worked on a metabolic resilience framework of an urban immune system across three scales: The property, the neighbourhood, and the city. Whereas the 'small' scale addressed by Katsuo et al. (2020) performed a cross-tabulation analysis between the level of project implementation and the level of stakeholder's engagement.

However, research works acknowledge that urban metabolism and circular economy analyses tend to be conducted at national or regional level, because of the availability of data. Consequently, top-down aggregate measures of resource consumption give a good baseline but are not necessarily useful to implement frameworks or practical responses for urban planning and design (Musago et al. 2017). Moreover, the lack of involvement of more localised actors impacts on the availability of such information.

In *Managing the Transition towards Circular Metabolism: Living 6 Labs as Co- Creation Approach*, Amenta et al. (2019) outlined an approach to address some of these challenges, through co-creation processes between researchers, experts and stakeholders, using Living Labs (LLs) as public-private-people partnerships that are developed by applying an iterative methodology comprising five phases: Co-Exploring, Co-Design, Co-Production, Co-Decision, and Co-Governance. At this point, would be interesting to see how the holistic vision that Paiho et al. (2020) define as complex systems in which economy, infrastructures, networks and resources are intertwined, can be embedded into the application of living labs, to understand those links by localness, geographical closeness, urbanism, and specific cultures.

In the next section, a summary of the knowledge gaps is presented, as well as the connections between the advancements of the studies and the questions that remain lacking exploration.

2.5 KNOWLEDGE GAPS

Both academic literature and industry-led reports on circularity in cities have increased in the last decade. After reading some of the most recent papers and reviews available, a general picture of the state-of-the-art can be drawn to identify some gaps. There is a wide range of opportunities for future research about the perception of circularity and sustainability by a wider range of stakeholders, the actual impacts of CE initiatives at the triple bottom line, and their influences on innovation systems (Geissdoerfer et al. 2016). Some conceptualisations have been made to clarify what a circular city is, but its definition is still open and developing (De vita et al. 2019) and some papers call for further clarifications on the representation of circular cities and the dimensions of a circular urban ecosystem (Williams 2019a, 2019b). Discussions on the levels and scales of circularity and its spatial representation are still at a young state, lacking academic contribution (Ibañez 2019) and the notions of urban metabolism have been widely used as an accounting approach but are rarely associated to urban interventions (Perrotti 2020).

Some other authors stressed that the application of the circular economy in cities lacks of explicit social involvement (Marin and De Meulder, 2018). The values and socio-cultural structures underlying the potential of CE remains largely unexplored (korhonen et al. 2018). Also, more knowledge is needed in terms of key actors involved, types of activities, infra-systems, resource flows and further research to determine how context affects the actions taken in cities (Williams, 2019a, 2019b). Although some works questioned the socio-spatial implications of circularity in urban areas, they did so mostly to re-conceptualise the circular economy. We lack, therefore, evidence-based account explaining where and how this notion can be mobilised in environmental governance and planning (Savini 2019), so that other than redefining, more recognition could be given to CE as a dynamic, practical and spatial concept.

The literature identifies data availability as a limitation, and the role of academia is key to overcome those gaps. Some Chinese cities have experienced transition stages in the last decade, and many European/Nordic cities are self-proclaimed as circular cities. However, there is a long way to follow in terms of research on the nuances of circularity and its linkages with the sustainable and climate action agendas. Academic frameworks for multi-dimensional circular cities aimed to its practicability are missing (Marin and De Meulder, 2018) and so are indicators that respond to measuring circularity at an interconnected city-scale (Paiho et al. 2020).

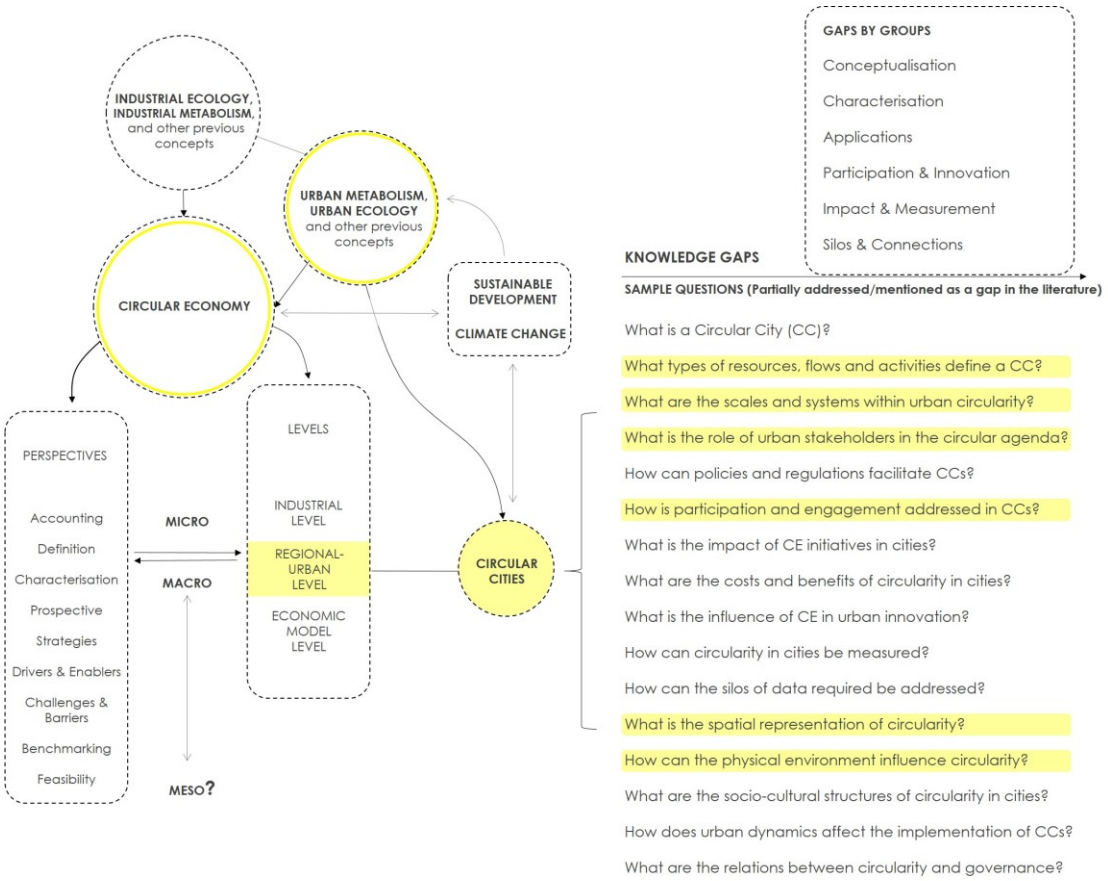


Figure 8. ***Diagram showing partial knowledge findings and gaps on circular cities.***
Own edition, based on the selected literature reviewed in all Chapter 1 plus own thoughts.

In Figure 8 a general summary of the ideas surrounding the circular economy in cities, the different approaches used in recent studies to analyse circularity, and some typical concepts involved with circular cities are shown. The sample questions that arose both directly and indirectly from the literature review, helped to orientate the issues this project intends to address, which aims to build more solid knowledge on what urban circularity means and how it can inform decision makers especially at the city/local scale, where spatial planning/design and related socio-spatial issues are directly interacting with the circular processes. Thus, this research contributes to the following investigative questions:

- What are the resources, flows, scales and systems that define a circular city from the urban planning perspective?
- How can circularity inform local authorities and engage stakeholders?
- What is the socio-spatial dimension of circularity in cities, and how can spatial planning influence it?

CHAPTER 3

3 INTRODUCTION TO CIRCULAR GLASGOW

This chapter briefly introduces Glasgow as the case study selected to bring understanding about the issues considered in the investigative questions. First, introducing the city and some basic information to later describe what the Circular Glasgow initiative is. This section does not cover a baseline analysis, instead it aims to describe the context considered as premises for the project.

3.1 THE CITY

Glasgow is the largest and most populated city in Scotland, with circa 624,000 inhabitants (Understanding Glasgow, 2018) and a surface of 177.3 km2 after Rutherglen and Cambuslang were transferred to South Lanarkshire in 1996, which resulted in a current density of approximately 3,500 people per km2. However, the Greater Glasgow region has a population of circa 1.2 million (Ibid). Most of the population within Glasgow City Council live in flats (tenements), which are the most common residential type of building in the city. The Figure 9 shows the location of the city and its administrative boundary, which was considered for the data collection, mapping and analyses carried in this project.

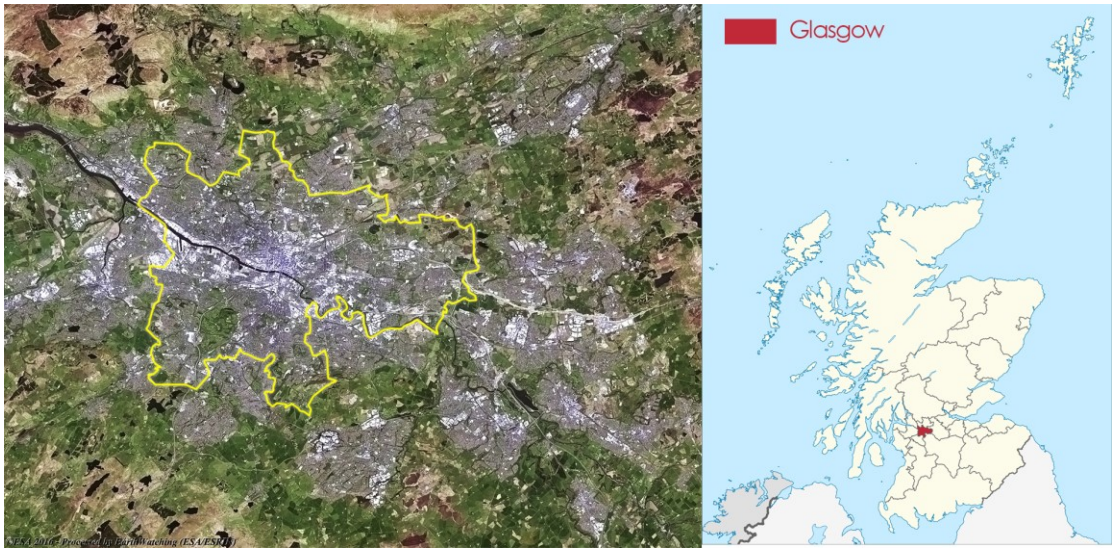


Figure 9. ***Location of the city of Glasgow.***
Adapted from Earth.esa.in (2016)

In the past, the city had a powerful position followed by a strong decline stressed by some unfortunate policy approaches taken during and shortly after the 50-60s; large-scale relocations, some functional and socio-spatial issues resulting in conflicted urban management measures and the decrease of population (Keating 1988; Wannop 1990; Tucker 2008) in the middle of a post-industrial transition that would also affect the future of the local economies of Glasgow (Reed, 1999).

After a shift from the development-led approaches, along with other efforts aimed at changing the image of the city following the 80s, Glasgow started recovering slowly getting noticed again among its peers in terms of competitiveness. Regeneration processes were leveraged by the momentum gained through city marketing milestones such as the branding campaign 'Glasgow Miles Better' (1983), and other events and titles that followed; National Gardens Festival (1988), European Capital of Culture (1990) and the British City of Architecture & Design (1999). The consequences of the urban decay that characterised the second half of the 20th century, left some socio-spatial footprints in Glasgow which nowadays are still part of the pending challenges to overcome, remaining as the signs of a long-term dereliction and deprivation which has been also associated to health issues that have affected the city (Maantay 2013, Maantay et al. 2015 Mcdonald et al. 2018) and its collective perception.

According to the latest official reports, Glasgow accounts with 1007 hectares of vacant and derelict land, 45% of which are of public property (Ordnance Survey 2020). This has a strong social implication as to 44% of the population in Glasgow lives within the 20% of most deprived areas (SIMD 2020) which can be observed in Figure 10.

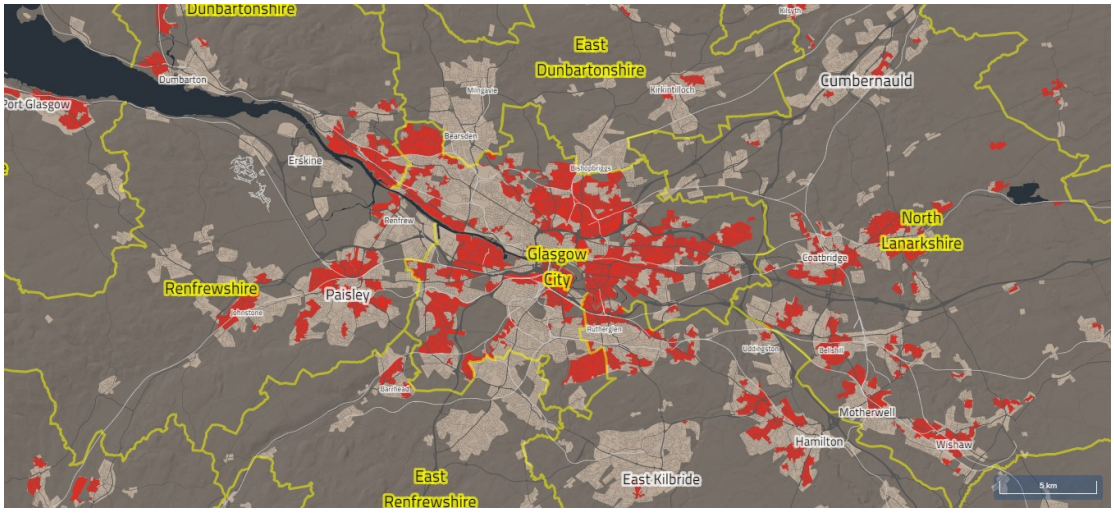


Figure 10. ***Scottish Index of Multiple Deprivation 2020, Glasgow 20% most deprived.***
Source: Scottish Government, retrieved from www.simd.scot

In 2010, the 'Sustainable Glasgow' board was established with an aim at fostering greener approaches. Since then, this partnership between the local authority, academia and other organisations has supported different initiatives towards a sustainable city, such as the Resilient Glasgow (2014) membership in the Rockefeller Foundation's project 100 Resilient Cities, the regeneration projects that accompanied the Commonwealth Games (2014) and the Glasgow's Green Year Agenda (2015) as a runner up for European Green Capital.

In 2016, another partnership was established, this time led by the Chamber of Commerce and funded by the organisation 'Zero Waste Scotland' with the intention of becoming one of the pioneering cities implementing the circular economy principles in the UK. A goal that came at the same time Glasgow is running the race towards becoming the first net-zero carbon city in the UK (GCC 2019).

Circular Glasgow is supported by the board of Sustainable Glasgow, which is also connected to other upcoming events such as the COP 26 (2020-21) and the Climate Emergency Working Group (2019), another board that joins the collaborative task force to leverage different perspectives of achieving a greener future for the city.

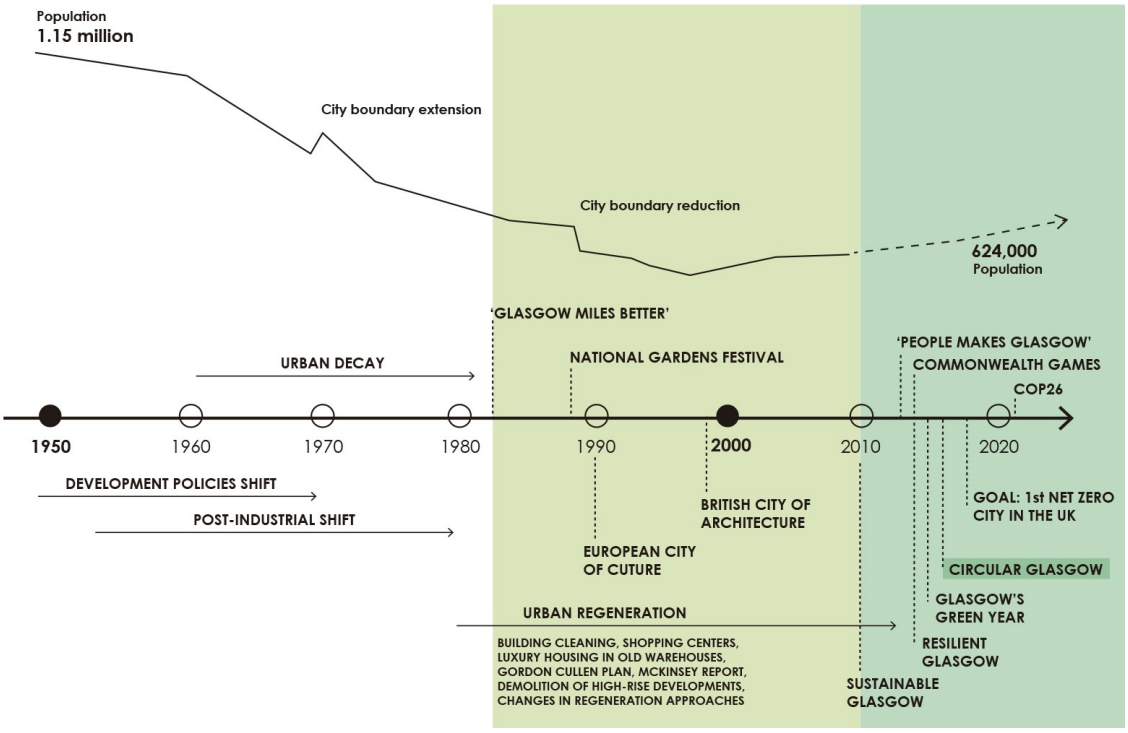


Figure 11. ***Glasgow's planning highlights.***
Own edition based on GCC City Centre Living Strategy (2019), Gomez (1998), and own additions

3.2 THE CIRCULAR AGENDA

The Circular Glasgow partnership completed Circle Economy's Circle City Scan in 2016 and identified the sectors with the greatest circular potential; Education, Healthcare and Manufacture (Figure 12), which provide 117,000 jobs and represent a quarter of the city's economic value (Circle Economy 2016). With a switch in the way it uses resources, Glasgow has an opportunity to increase productivity, leading to the sustainable wealth and wellbeing of its citizens (Ibid), something that is aligned with the sustainability agenda of the city, reinforced since 2010. All these efforts are now embracing the circular economy to go alongside the city's economy strategy.

Figure 12. ***Consumption of the three key sectors for Glasgow's Circular Economy.***
Source: Circle Economy (2016)

From the Circle Scan, among the three identified sectors the manufacture industry, with an economic value of circa £329.7 million, has the greatest circularity potential (Circle Economy 2016) and the emphasis on food and beverages sectors within it resulted in a first pilot project: turning unsold bread into beer, and other ventures that are expected to be scaled up to create more circular jobs, currently representing only 6% of the jobs in the city (Circle Economy 2018).

According to a report from Circle Economy (2018) The city shows great potential when it comes to the variety of job types it could create, furthermore, the City Council announced the establishment of a Circular Route Map for the city (Clark and Gille, 2019). This last is currently under development. However, as in many other cities figuring its way to become circular cities, the circularity in Glasgow is still being shaped and translated into practice. Moreover, taking the concept into the urban field is still an ongoing process, and that is where the reason of this project lies, expecting to contribute to the discussions between the relevant local stakeholders, from local actors to a broader audience of practitioners and policymakers.

CHAPTER 4

4 METHODOLOGICAL APPROACH

This chapter introduces the methodology used in this dissertation to achieve the objectives proposed and answer the investigative questions addressing some of the knowledge gaps mentioned in Chapter 2. first, the research design adopted is defined, following the phases and specific methods used. Each method is described along with its inputs and the format of the expected outputs. Finally, an overview on the methods is summarised into a diagram to better illustrate the steps and its connections surrounding the *How* and *Where* of urban circularity.

4.1 RESEARCH DESIGN

This study follows a cross-sectional and pragmatic approach, presenting both qualitative and quantitative methods that best suit each milestone of the research. The pragmatic approach helps to get a broader perspective by collecting and analysing data in a combined way. It is suggested that this kind of approach enhances the development of knowledge in social sciences and multidisciplinary projects (Onwuegbuzie & Leech, 2005).

The design of the research is comparative-descriptive with an exploratory perspective, since it is based on the review of different sources of information to identify alignments, describe findings and suggest further steps. In order to answer the research questions and meet the objectives of this work, the research methods are grouped into two phases of study; (1) Understanding and (2) Localising. Each of them with qualitative and quantitative data collection and the application of analysis tools mainly based on literature review, semi-structured interviews with key stakeholders, content and thematic analysis through diagrams, tables and maps to visualise and compile findings.

Although the information from the first phase conforms an overview of urban circularity towards a general theoretical framework. It is the linkages to socio-spatial aspects relevant to the spatial planning what is the key subject of the work. Thus, more attention has been put on those in the second phase (Localising).

4.2 PHASES, METHODS AND INSTRUMENTS

*4.2.1 Phase 1: **Understanding** urban circularity*

In such a recent subject as circularity in cities it is necessary to review the context of what has been discussed, not only from the academic perspective but also industrial and practitioners visions. In this sense, prior to the specificity of the socio-spatial dimension and variables, the first phase of this thesis focused on the collection, review and synthesis of theoretical information and professional reports on (**A**) the theories and concepts in which the circular economy is inserted, to later (**B**) identify key information on the urban implications of circularity to (**C**) come up with a comprehensive and visual understanding of the circular city model.

The research methods that build up this phase are:

- Literature review

  The collection and review of recent papers and reports to get a general view of the state-of-the-art to describe the circular economy, its definition and related concepts. The literature offered knowledge of the common approaches, authors and potential for further study. The primary sources of literature used were focused on (not limited to) papers, guidelines, reports and others documents that have interconnected concepts, compiled indicators, and/or formulated CE frameworks; and have addressed the implications of CE in cities. All these formed the base for a tailored understanding of urban circularity which later supported the case study selected.

- Content Analysis: Benchmarking

  Alongside the theoretical review, major attention was put on academic papers, institutional reports and case studies that identified approaches, strategies, indicators and other properties of circular cities agendas. This helped to get a collective view that was later compiled with own thoughts, resulting in the visualisation and description of the theoretical framework to feed the case second phase (see Chapter 5 section 5.1).

*4.2.2 Phase 2: **Localising** urban circularity*

Following the general understanding from phase one, the second phase of this thesis focuses on the empirical case study to (**A**) Understand the connections and alignment of local initiatives and agendas directly or indirectly pursuing sustainable solutions and the views from stakeholders on the circular economy in cities for later (**B**) selecting and interpreting sample data as inputs for the spatialisation of variables that could illustrate the key socio-spatial issues identified in Glasgow and finally (**C**) describe examples of certain planning components from the lens of urban circularity.

The research methods that build up this phase are:

- Case study

  According to the descriptive and exploratory scope of this research, the case study served as a specific context to integrate and visualise qualitative and quantitative data. Despite the disadvantages of case studies to make generalisations, they base some findings and conclusions that can be useful for further exploration, for example regarding the spontaneous or unlabelled initiatives that could be associated to circular practices.

- Focused literature review

  The literature review for this second phase of the thesis looked for inputs from the review of local official documentation, specific spatial plans and data from public institutions.

- Interviews

  The interviews offered insights to define a vision on circularity in cities as seen by key specialists and/or groups. As a method, it helped to gather qualitative data and get feedback related to the suitability of the circular movement in Glasgow and their conceptual interpretations. The interviews were semi-structure, firstly addressing the meaning of CE within urban areas, as well as the particular components (enablers and barriers) of the circular agenda from the planning perspective. The interviews were done entirely online, conducted in English and taking between 30 minutes to one hour. The outcome was represented as a combined thematic diagram.

- Tables, diagrams and maps

  The generation of matrixes helped in defining criteria, comparing characteristics, and the diagrams and maps informed the visualisation of results and the elements studied in this research.

The next diagram (Figure 13), shows an approximation to the design of the research and the process in phases and milestones, as previously described. Similarly, the connections between steps, questions, and the objectives of the research are also drawn in the following diagram (Figure 14).

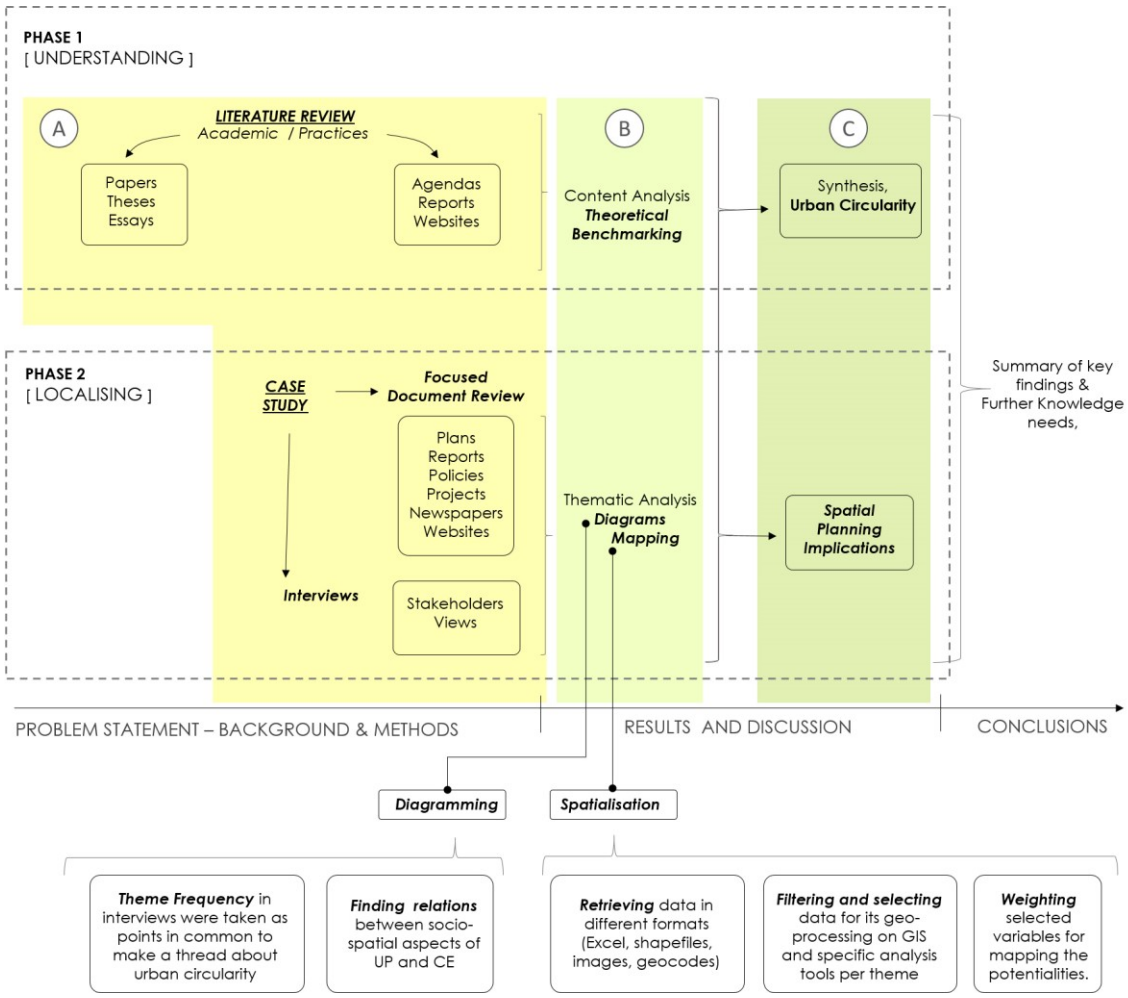


Figure 13. ***Structure of the research.***

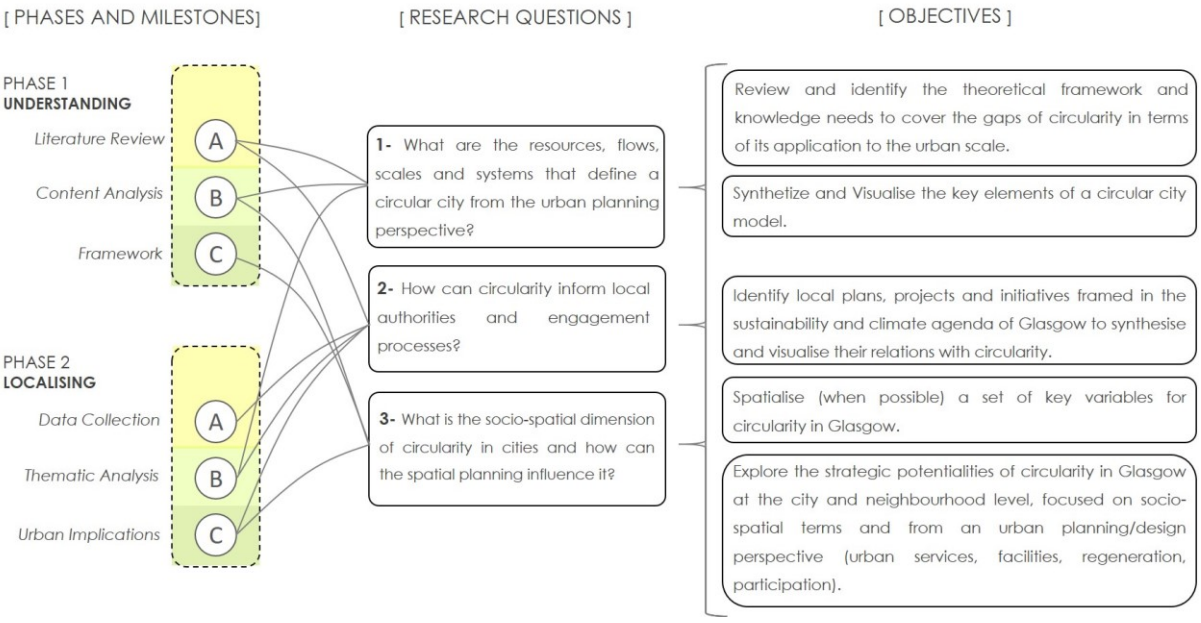


Figure 14. ***Connections between research questions, objectives and phases of the methodology.***

4.2.3 Sampling

For the literature review process; papers, reports, plans, and other documents were found by carrying an online scanning through search engines using sentences combining the three main topics of this dissertation i.e. circular economy, urban planning and climate action: bringing results for 'circular economy', 'circularity in cities', 'circular economy in cities', 'urban circularity', 'circular cities', 'circular economy and planning', 'circular economy and climate change', 'circular management' and so on, which consequently brought other concepts that were found relevant for further search because of their frequent presence on the main papers: urban metabolism, LCA, MFA and transition movements.

Similarly, for the sampling of interviewees the selection was done according to the knowledge required from the participants which in this case started by the stakeholders directly involved with the *Circular Glasgow* agenda and the organisations that were connected with the urban practice of Glasgow. Also, an open non-probabilistic sampling coming from snowball recommendations from the first stakeholders was considered. The table below shows a list of the organisations in which contact with interviewees was established (Table 1).

Table 1 ***List of organisations contacted for the interviews***

	Organisation Name	Type and relevance	Field
Circular Glasgow Partners	Glasgow's Chamber of Commerce	Public Sector, Main *promoter of Circular Glasgow*	Business and Commerce
	Glasgow City Council	Public Sector, *Key supporter of planning for Circular Glasgow*	Urban Planning and Design
	Zero Waste Scotland	NGO, *Key finantial and knowledge supporter of Circular Glasgow*	Sustainability and Environmental Management
Academy	Glasgow Caledonian Univerity	University, *Academic Partner of GCC for some projects of Sustainable Glasgow*	Building Services and Environmental Management
	Glasgow School of Arts	University, *Academic Partner of GCC for urban projects.*	Architecture and Urbanism
Organisatios and Industry	Architeture and Design Scotland	Organisation with a*ssociated projects with GCC*	Urban and Community Development
	Metabolism of Cities	NGO, *Urban Metabolism promoters working on Horizon2020 project on Circularity*	Urban Metabolism and Circular Economy
	Plannig Aid Scotland	NGO that s*upports community planning practice in Scotland*	Local Planning, Community Engagement and Participation
	Resource Futures	Private Consultancy, *Working on Circular Economy Statements for cities in the UK*	Resouce Management
Others	This Big City	e-Magazine, *Sustainable cities content curator/creators from Edinburgh*	Sustainable Cities

4.2.4 Data analysis - Content analysis

In each of the phases and steps described above, the analysis of information was based on classic content and thematic analyses to produce both quantitative and qualitative outputs, descriptions, and comparisons in a systematic and objective way (Berelson 1952, 489 as cited by Linder et al. 2017). For the processing of data; tabulation and mapping methods form the backbone of the selected formatting. In that sense, specific aspects were operationalized/defined to facilitate comparisons, the spatialisation, and the interpretation of interviews.

Assessment of urban initiatives

To associate the elements of the circular economy to cities, a basic set of urban components were selected; considering 3 dimensions of scopes (economics, natural and built environments,) and 3 types stakeholders (government, businesses and social actors). Finally the transversal element of planning (policies) is also considered. All these, summarised as the 7Ps in Table 2, are based on a revision of assessment frameworks for sustainability and circularity that were found relevant for this thesis (Elkington 1994; Girard & Nocca 2018; OECD 2016). This 7Ps were mainly used for the identification of the nexus between circular initiatives and the main elements of city planning, scoring these connections between Low (1), Medium (2) or High (3).

Table 2 ***7Ps for a comprehensive vision of the urban components***
Own elaboration, based on selected literature reviewed namely, the 3BL by Elkington (1994), the Circular city integrated evaluation tool by Girard & Nocca (2018) and the 3Ps Framework by the OECD (2016) with own contributions.

Planet	Prosperity	Places	Policies	Public	Private	People
Strategic focus				Stakeholders		
Natural Environment	Economics	Built Environment	Regulations, Plans, Programmes, etc.	Institutions	Business	Social
		Significance/Sensibility		Low	Medium	High

Interview process

The interviews were intended to gather some general and localised insights about circularity in Glasgow but also giving hints on cities in general. The semi-structured set of questions that guided the conversation is shown in the diagram below (Figure 15).

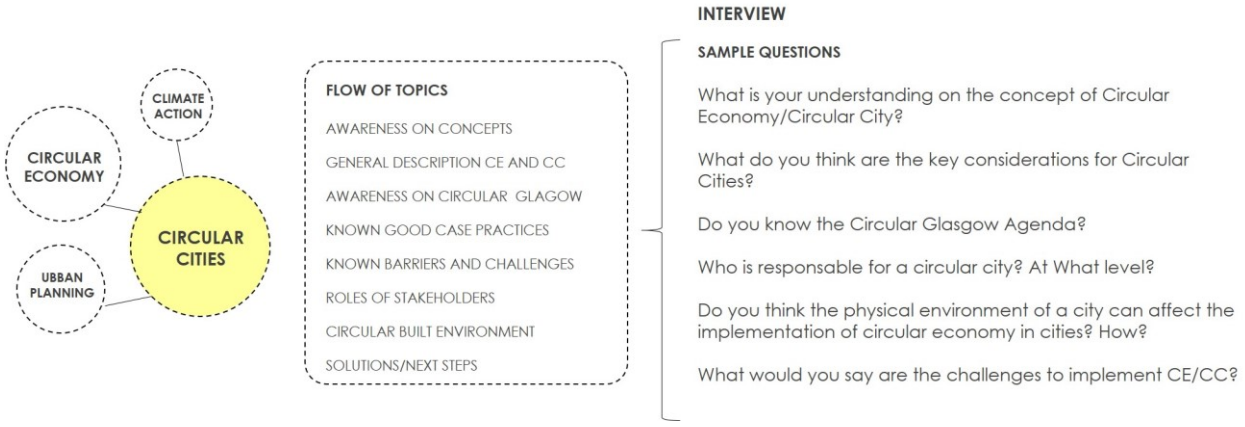


Figure 15. ***Semi-structure of the interview and sample questions.***

Mapping process

Three themes were considered as the key data streams (Figure 16) to compile both quantitative and qualitative aspects of the socio-spatial dimension of circularity; First, The physical theme which helps to recognise and group properties and characteristics of the built environment, seen as the settings that could impulse, or slow down circular solutions, highlighting the relevance of the urban fabric as it influences the metabolism of cities (Thomson & Newman 2018; Musago et al. 2017) in terms of the stock and flow of materials and *Wastescapes*[10] (Amenta & Van Timmeren 2018, Figure 15) and other underutilised built assets (Appendino et al. 2019; De Vita et al. 2018). Second, the functional theme groups aspects that facilitate circularity according to certain urban activities, types of local production and services that lead the city as a service (Circle Economy, 2018), and finally, the social aspects relevant to foster not only well-being and behavioural changes, but together with the functional and physical aspects can encourage urban innovation and incremental changes towards urban transitions (Amenta et al. 2019; Transition Network 2016).

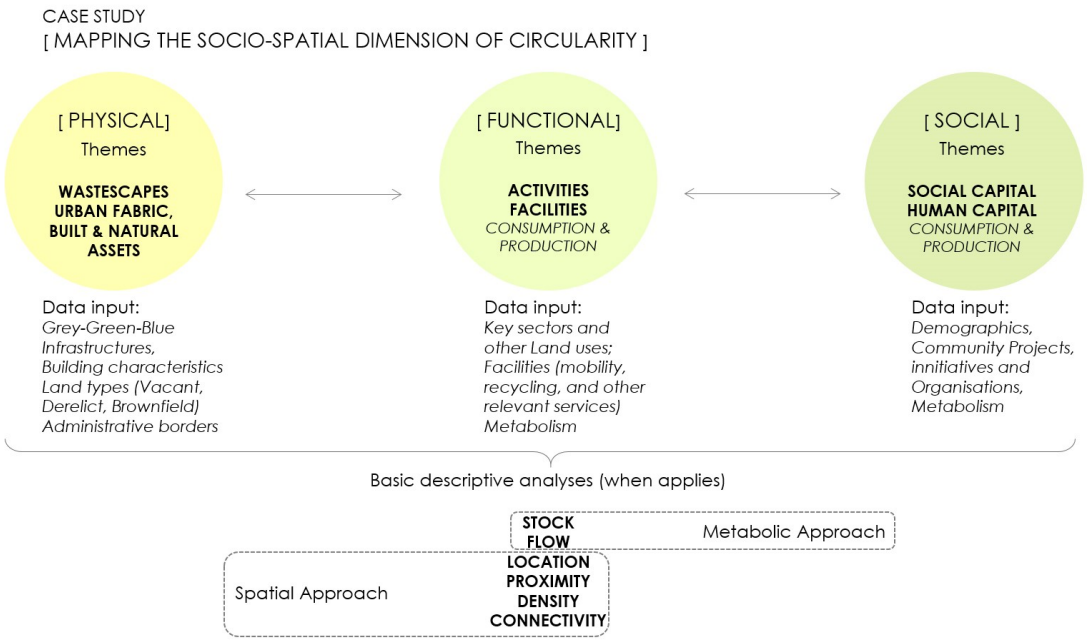


Figure 16. ***Thematic clusters for spatialising variables relevant for circularity.***
Own elaboration, based on the ideas of Thomson and Newman (2018), Musago et al. (2017), Amenta & Van Timmeren (2018), Appendino et al. (2019), De Vita et al. (2018), Amenta et al. (2019) with own contributions.

[10] Wastescapes, as defined by Amenta & Von Timmeren (2018) encompasses the word 'Waste' as unused objects, substances, and/or material and 'Scape' as spatial characteristics. Thus, the term wastescapes can be used to address polluted lands, brownfields or land in a waiting condition and/or the results of simultaneous urban growth and shrinkage, which constitute operational and infrastructural waste

In total 10 sets of maps were generated to illustrate different topics, according to the most critical urban layers/systems. Data was collected from multiple sources; digital platforms such as Digimap and Geomni, official reports, planning documents, and other open sources; such as the UBDC (Urban Big Data Centre). The own processing and spatialisation of records was also necessary.

Some maps are descriptive, made by arranging and overlaying thematic data to draw comparative results, whereas other maps are more analytical, for which more complex data processing and operations were used to come up with the results. The general sources and data processing carried are described in the Table 3.

Table 3 ***Thematic clusters for spatialising variables relevant for urban circularity (Continues)***

Systems	Map section	Description	Key Data sources	Data processing and GIS tools
Socio-productive	Distribution of public facilities for waste recycling	Distribution of waste collection points in the city of Glasgow. Provision of bins that include special waste streams, such as mixed glass, textiles, oils and others.	CSV Public Recycling Sites within Glasgow City Council. (UBDC -Urban Big Data Centre - University of Glasgow 2013)	A CSV with the addresses was retrieved from the UBDC portal, an open source tool from google drive to geocode those addresses was used and a column with the coordinates was then brought into shapefile by using the option of 'Join and Relate' in Arcmap. following this, an 'Euclidean Distance' analysis was performed to establish a gradient of proximity by walking distances: (a) up to 100 meters, (b) 100-300 m and (c) 300-500 m.
Emergy and Mobility	Mobility facilities and patterns	Distribution facilities that encourage sustainable mobility such as walking, bikes or electric cars, also considering the mobility choices of the population and the characteristics of the physical environment.	Shapefiles: 'Point of Interest' (Ordnance Survey, March 2020), Topography shapefile (Ordnance Survey, November 2019). Next Bike Stations (ArcGIS Online map by GCC), Database: Share of people that goes to work/study by foot and Share of people that own/drive 2 or more cars (Excel Workbook by Neighbourhoods: Understanding Glasgow Project (UGP), based on the 2011 Census).	For this mapping section, two maps were intended to show the provision of facilities that could encourage sustainable patterns of mobility. Electric Car Chargiing points, and Car Hiring Providers were extracted from the 'Points of Interest' shapefile through the 'Selection by Attribute' tool. Then, this information was 'Merged' in a single layer with the layer of Bike Sharing Stations (Next Bike scheme). On the other hand, for the social part, population statistics on car ownership and trips by foot from the Excel sheet (workbook by UGP) were associated to the neighbourhood polygons on GIS. Finally, the 'Spatial Joint' and 'Field Calculator' functions were used to estimate the the share of pedestrianised spaces versus the share of vehicle-oriented spaces, by extracting the areas of the polygons from the Topography shapefile of the city, later merged into cells of 300 x 300 meters.
Emergy and Mobility	Renewable technologies	General clusters of installed technologies, critical demand and targeted areas for future projects of renewable energy in Glasgow	Reports: Energy and Carbon Masterplan 2013, Carbon Management Plan 2013-2021.	This layer was done by digitizing and georeferencing the scanned maps from the reports mentioned on the left column, to then draw the overall clusters of initiatives. It does not involve any geoprocess or analysis itself, the objective was to get a visual overlay of the current conditions and future projects that might impact on the energy demand of Glasgow.
Natural and Econological	Green and Blue Surfaces	Distribution of urban parks, local allotments and main streams of water in Glasgow	Shapefiles: 'Point of Interest' (Ordnance Survey, March 2020). OS Open Green Space and OS Open Rivers (Ordnance Survey, April 2020). PAN 65 Open Space 2008. Park Power Methodology (Greenspaces Scotland 2020)	For this map, the green spaces layer was curated, eliminating categories that do not offer dynamic functions in the public realm, for example; the private green spaces. Similarly, some other categories of public spaces were cleared to meet the basic criteria from the methodology of Park Power e.g. 'Play space', 'Religious Ground and Cemeteries' and 'Golf Courses' were excluded. Thus, the resulting map integrates a view of the Green and Blue surfaces of the city with general theortical potential for ecosystem services and landscape enhancment. Additionally, the point shapefile showing community growing spaces is included over the main map.

Systems	Map section	Description	Key Data sources	Data processing and GIS tools
Property and built assets	Material stock in buildings	Total of material (Glass, Aluminium, Copper, Steel, Concrete and Wood) in residential and commercial buildings in Glasgow,	Shapefiles: Building Height Attribute (BHA) (Ordnance Survey, October 2019) and UK Buildings shapefile: Residential and Non Residential Classification (Geomni-Digimap, version 2019). Material Indicators: Global material stock and flow model, Residential: Marinova et al. 2020; Non Residential: Deetman et al. 2020.	Once the shapefile from buildings was arranged (Classifying and combining the attributes of use and height) the 'Select by Attribute' function on ArcGIS was used to find the features that matched the categories of buildings for which material indicators were available. For residential: 4 types of residential buildings, namely: (a) detached, (b) row houses, (c) apartment buildings, (d) high-rise. These were determined according to the following heights by amount of floors: (a) <=2; (b) >2 <=6; (c) >6 <=12; (d) >12. The height attribute was given in meters. Thus, an assumption of 4m per floor was used to estimate the amount of floors considering the building plates and roof structures. For non-residential buildings 12 categories were used among variations of Commercial, Retail, Offices and Community buildings. For each category of material (Wood, Concrete, Copper, Steel, Aluminium and Glass) the values were found in Kg per m2. Hence, the floor area of each building was multiplied by the number of floors, and then by the amount of each material, resulting in the estimation of material per building. The option 'Field Calculator' was used to make the basic operations required. Finally the 'Spatial Joint' geoprocess was used to summarise and visualise the information as shown in the grid (300x300 m) for all the city in rounded ranges. This was done both for separate materials and the total sum of them.
Property and built assets	Wastescapes	Concentration of wastescales in Glasgow, classified among 3 types.	Shapefile: Vacant and Derelict Land (VDL) (Ordnance Survey, January 2020), CSV converted to shapefile from 'Buildings at Risk' Register (www.buildingsatrisk.org.uk) and 'Point of Interest' shapefile (Ordnance Survey, March 2020). Definition and classification of 'Wastescapes' by Amenta and Von Timmeren (2018)	Once the three categories of wastescapes: WS1: Vacant and Derelict Land; WS2: Vacant and Derelict Buildings and WS3: Dross from Infrastructure (this last was extracted from the topography shapefile as 'roadside natural land', which also coincided with the category of 'green corridors' in the green spaces shapefile) were organised in layers from the different sources, their area was calculated using the function of 'Calculate Geometry' on GIS. Moreover, the 'Spatial Joint' geoprocess was used to summarise and visualise the information as shown in the grid (300x300 m) for all the city. It was neccesary to perform an 'Intersect' geoprocecss to the WS1 and WS3 polygon layers in order to be clipped onto the grid, resulting in a precise sum within each cell. Finally, a qualitative range from very low to very high was used to display the amount of wastescapes per map cell, using 5 natural breaks (Jenks).
Property and built assets	Recycled land and build assets	Amount and location of building and land reurposing initiatives.	Shapefiles: ArcGIS online map Stalled Spaces (Glasgow City Council) re-drawn from the web version. Google Maps search of particular repurposing of buildings, case by case to map them out.	The locations of good-case practices in terms of building repurposing was surveyed manually,through google maps and converted into a points shapefile that was then merged with a point shapefile collecting the stalled spaces initiatives. The clusters were identified by observation and no geoprocessing was required because amount of entries was manageable. However, a simple overlay of layers allowed the comparison between the location of these reusing/repurposing initiatives against the stock of wastescapes previously calculated.
Socio-productive	Distribution of Circular Businesses	Distribution of Circular Businesses in Glasgow, according to selected core categories of circular activities	Shapefiles: 'Point of Interest' shapefile (Ordnance Survey, version March 2020). Report: Employment in the Circular Economy (Circle Economy 2018)	The function of 'Selection by Attribute' was used to curate the categories within the commercial and retail sector from the shapefile of 'Points of Interest' of Glasgow. The tool of 'Kernel Density' was performed to visualise the areas with more concentration of Circular Businesses. Apart from the visualisation of the map, the table of attributes was exported to Excel in order to do basic operations to classify and calculate the share of each business category to then represent the share of each one and make comparisons thourgh charts.
Socio-productive	Distribution of community levers and social entrepreneurship	Distribution of public community facilities and an approximation to social capital by taking a look to the distribution of the population that runs smalls businesses and the population that participates in local initiatives and calls.	Shapefiles: 'Point of Interest' (Ordnance Survey, March 2020). Database: Share of Entrepreneurs (Excel Workbook by Neighbourhoods: Understandng Glasgow Project UGP, based on the 2011 Census) . Report: Sourcing City Data from Citizens (Open Glasgow by GCC: Technology Strategy Board, 2015)	For this map, two main layers show the provision of the public facilities like Community Halls and WiFi Hotspots extracted with 'Selection by Attribute' from the 'Points of Interest'. Later on the function 'Euclidean Distance' was performed to determine four ranges of walking distances: (a) up to 300 m; (b) 300-500; (c) 500-800 (d) 800+. On the other hand, for the social part, quantitaive information from the population statistics on entrepreneurship (UGP) and other stats from the report 'Sourcing City Data from Citizens' were associated to the the Neighbourhood polygons on GIS and then combined to draw a general theoretical social capital per Neighbourhood (Althought this measurement is not intended to express what all the social capital means, it focuses on participatory planning and business entrepreneurship stats)

After the 10 sets of maps, a final combined analysis was made taking the inputs from different layers previously obtained. A multi-criteria set of variables was selected with an emphasis on the stock of socio-spatial aspects rather than the metabolic flow of these. In other words, the circularity potential that this last analysis intends to show, responds to physical settings, provision of facilities and demographic conditions rather than direct energy and resources flows. Hence, represented through the stock of practices to visualise potential performance. The weighted multi-criteria scorecard is presented in Table 4.

The final combined map required the pre-processing of the different variables selected. In order to use the 'Weighted Sum' and 'Weighted Overlay' of ArcMap, all layers were converted into Raster using the conversion tools, 'Feature to Raster', and then reclassified using the 'Reclass' section of the 'Spatial Analyst Tools' to assign them values ranging from 1 to 4 points according to thresholds defined in the scorecard. Some assumptions were made in terms of walkability choices, distances, share or relative amount of certain variable and the own criteria for what could be considered as low or high potential performance in the local context with the available data.

Once the 'Weighted Overlay' was obtained, the 'Zonal' section of the 'Spatial Analyst Tools' was used to bring zonal statistics into the neighbourhood boundaries, so that an approximation to the circularity potential by neighbourhood could be visualised. Although similar, the 'Weighted Sum', different to the 'Weighted Overlay' served to bring a more detailed view of specific zones by looking at the values obtained by pixels. In that sense, the internal distribution of the practices and features that could contribute to circularity within the neighbourhood are better observed.

Circular urban practices

Based on the whole two phases of the research, the last part of the results comprises a compilation of examples and implications of urban planning in the direct or indirect delivery of urban circularity. This was carried by tabulating good case practices and examples of initiatives and metrics suggested by the consulted sources to orientate monitoring process. Moreover, a final diagram exemplifies the circular flow of basic socio-spatial variables in a circular city.

Table 4 ***Multi-criteria for a socio-spatial perspective on the circular performance of neighbourhood***

SYSTEMS	ISSUES	TRANSITION ELEMENTS	INDICATOR	THRESHOLDS	WEIGHT
Emergy and Mobility Systems	Sustainable Mobility	Optimisation / Localisation	Proximity to charging points for Electric Cars by Euclidean Distance (m)	500-800: 1 point, 301-500: 2 points, 100-300: 3 points, Less of 100: 4 points	7%
		Functional Dematerialisation	Proximity to bike rental stations by Euclidean Distance (m)	500-800: 1 point, 301-500: 2 points, 100-300: 3 points, Less of 100: 4 points	8%
		Collaboration	Amount of people who travel to work by walking, bike or public transit (%) by Neighbourhood	1-25: 1 point, 25-50: 2 points, 50-75: 3 points, 75-100: 4 points	7%
		Optimisation / Localisation	Amount of pedestrianised (equiped) areas versus Road areas (%) by cell size in walkable area 300x300m	1-25: 1 point, 25-50: 2 points, 50-75: 3 points, 75-100: 4 points	6%
	Energy use	Collaboration / Bio-Regeneration	Average energy demand (Bands= Low to Very High: 1-5, based on STEP-UP)	Very high: 1 point, high: 2 points, medium: 3 points, low: 4 points	9%
		Bio-Regeneration /Optimisation/Looping and Adapting	Number of Installed renewable-sourced schemes for housing by Kernel Density.	very low: 1 point, low: 2 points, medium: 3 points, high: 4 points	11%
Built and Propety Systems	Environmental Health	Collaboration/Functional dematerialisation	Proximity to clusters of reports on litter, smell and other related disturbances in the public spaces by Euclidean Distance (m)	Less than 150: 1 point, 151-300: 2 points, 301-500: 3 points, more than 500: 4 points	3%
	Circular built assets	Looping and Adapting	Number of successfully repurposed buildings by Kernel density in walkable distance of a radius of 300 m	1: 1 point, 2-4: 2 points, 5-7: 3 points, 8 or more: 4 points	8%
		Looping and Adapting	Density of Wastescapes, by cell size in walkable area 300x300m	Very Low: 4 points, Low: 3 points, Medium: 2 points, High: 1 point, Very High: 0	3%
		Looping and Adapting	Number of vacant land repurposing (temporary) initiatives by Kernel density in walkable distance of a radius of 300 m	very low: 1 point, low: 2 points medium: 3 points, high: 4 points	7%
Socio-Productive Systems	Circular Business	Looping and Adapting/Functional Dematerialisation/Collaboration	Amount of Businesses that could be categorised into core circular activities (reusing, sharing, repairing, reclaiming, and so on) by Kernel density in walkable distance of a radius of 300 m	very low: 1 point, low: 2 points, medium: 3 points, high: 4 points	8%
	Waste Recycling	Localisation/Collaboration /Looping and Adaptation	Proximity to in-situ public recycling facilities by Euclidean Distance (m)	101-300: 1 point, 51-100: 2 points, 20-50: 3 points, Less of 20: 4 points	7%
	Community engagement	Collaboration/Localisation	Proximity to public community halls and similar facilities by Euclidean Distance (m)	500-800: 1 point, 301-500: 2 points, 100-300: 3 points, Less of 100: 4 points	3%
		Funtional Dematerialisation / Collaboration	Proximity to public wifi spots by Euclidean Distance (m)	101-300: 1 point, 51-100: 2 points, 20-50: 3 points, Less of 20: 4 points	2%
		Collaboration	Number of participants in a city-wide participatory processes by Neighbourhood (Absolute value, Open Glasgow 2015)	1-10: 1 point, 11-25: 2 points, 26-40: 3 points, 41 or more: 4 points	3%
Natural Systems	Community Gardening	Collaboration / Bio Regeneration	Proximity to community growing spaces by Euclidean Distance (m)	500-800: 1 point, 301-500: 2 points, 100-300: 3 points, Less of 100: 4 points	4%
	Actionable Green Spaces	Bio-Regenration	Density of green areas by cell size in walkable area 300x300m	very low: 1 point, low: 2 points, medium: 3 points, high: 4 points	4%
					100%

CHAPTER 5

5 RESULTS

The literature reviewed and the screening for circular initiatives from selected documents served not only to get a picture of the state-of-the-art and identify the knowledge gaps, but it also offered a conceptual framework for understanding how the circular economy concept has been embedded into some urban development agendas. Thus, this chapter contains the results from the analysis those documents, interviews, the case-study and other academic and non-academic sources, presented through diagrams, maps and other visual resources that summarise and communicate the findings towards a general proposal of an urban circularity framework, with an emphasis on the socio-spatial variables as key components that inform the urban practice.

5.1 SCHEMATISATION OF URBAN CIRCULARITY

The content from both academic and practitioners research show different approaches to circular cities. It was noticed that they varied according to the nature of promoters or authors varying in scopes, characteristics and principles. In that sense, the following section identifies and visually summarises the conceptual framework that informed the case study analysis and the final representation of urban circularity approach proposed.

5.1.1 Urban resources, systems and scales

To visualise urban circularity, it was important to first define what resources and systems apply to circularity in cities. Thus, as a way of summary and compilation of the findings in the literature, complemented with the vision of some stakeholders interviewed and

own adaptations, the diagram in Figure 17 sets a perspective from the 'circular' metabolism lens where, apart from the natural resources, takes into account the socio-spatial resources that also form part of the urban systems.

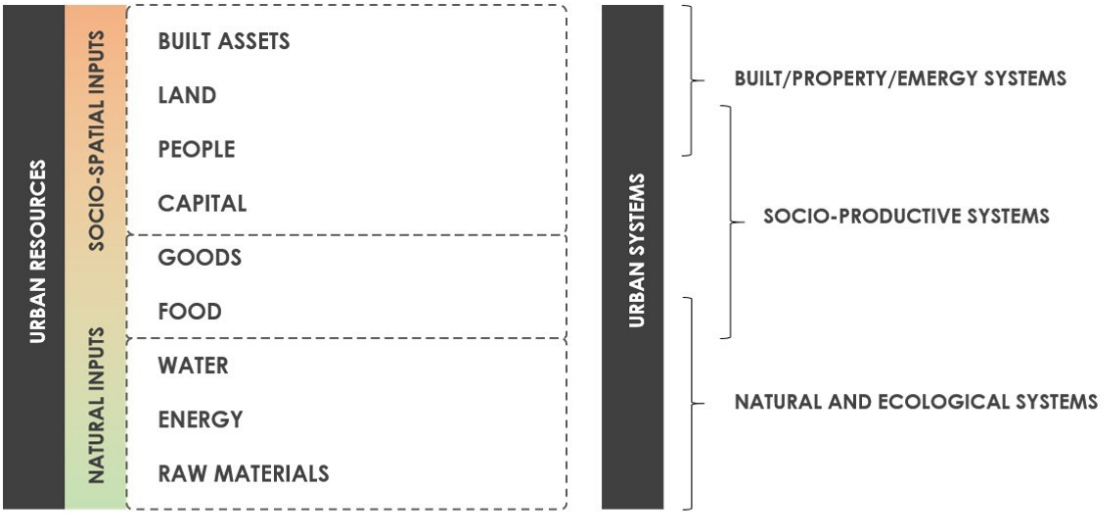


Figure 17. ***Urban resources for a circular metabolism in cities***

The socio-spatial section of the diagram is composed mainly by components of the techno-sphere i.e. built assets, products (food, goods) and other inputs that result from processes with embodied energy and materials. At the same time, the inclusion of people, capital and land – strongly connected to production and consumption activities – facilitates the understanding of a more holistic urban metabolism, taking into account aspects such as workforce, migration, competitiveness and other social processes that cannot be dissociated from neither economic nor spatial planning as they represent merging points between these disciplines, and could be levers to speed up common goals for the development of a circular city.

The spatialisation of systems that emerge from this resource-driven approach can be seen as layers, similar to those used in traditional urban analyses followed by other planning and design stages:

In the **natural and ecological system**, the blue and green infrastructure are of high relevance for circular planning processes towards bioregeneration and other environmental targets. Similarly, the **built and property system** are related to the management of land and buildings as urban assets with intermittent potential change, whereas the grey/built infrastructure (bridges, roads, pipelines, and other networks) configure a sort of **emergy and mobility system** that, apart from having slower

dynamics in terms of change (Wegener 2004 as cited in Dijst 2013) because they are usually designed for the longest term, this allows the flow/mobility of both natural and transformed/treated/digested resources from the source to final consumers. Finally, the **socio-productive system** integrates actors and their interactions with the production and consumption processes.

It must be clarified that, as in most complex systems, the urban systems are not truly isolated, they are intertwined. however, the Figure 18, simplifies these systems by layers that can be seen through the lens of circularity, as a way to help policymakers understand and explore possible opportunities by sectors and specific urban components and interventions.

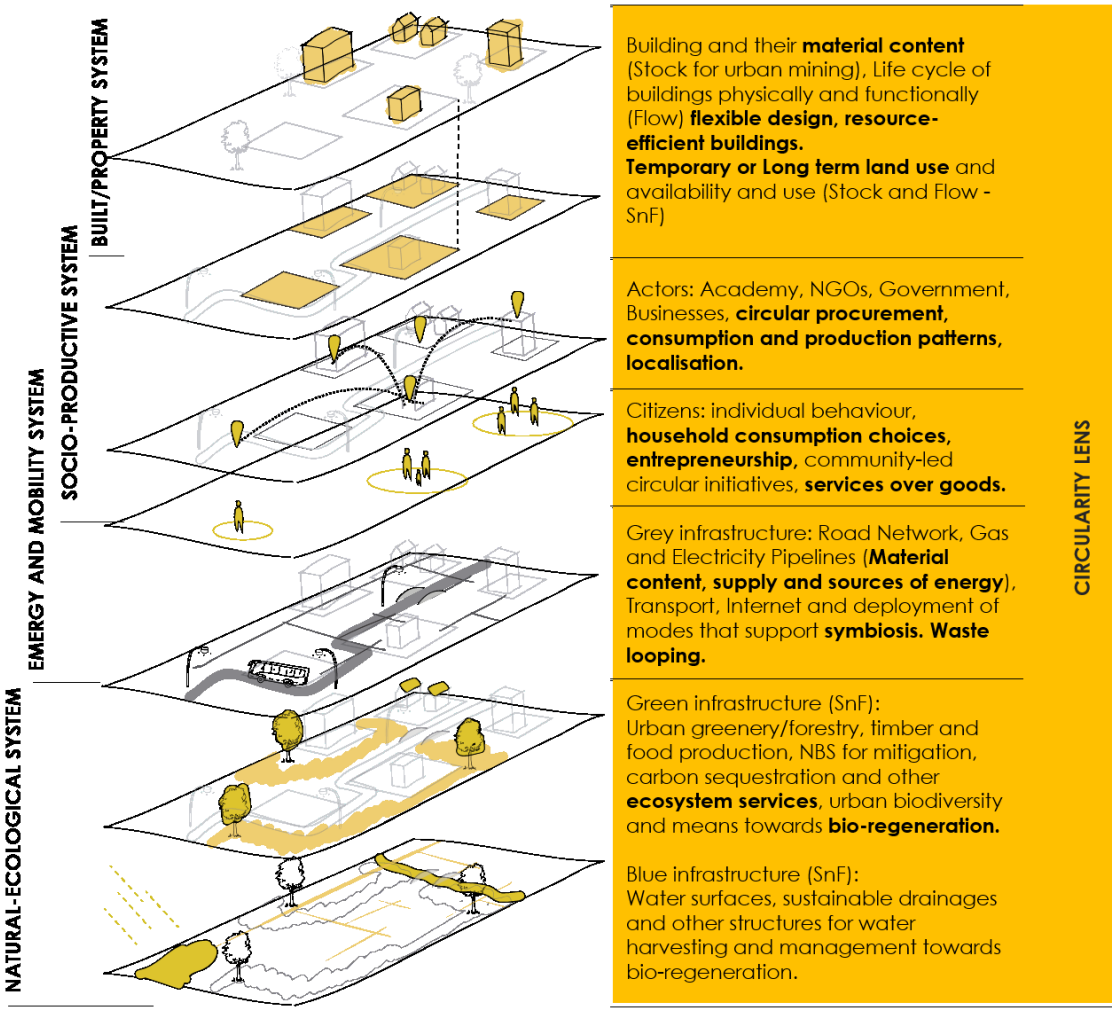


Figure 18. ***Urban systems through the lens of circularity.***

Additionally, as found in the literature, there was a need to figure out how the different scales of the circular economy could represent the interactions within/among urban systems in order to set actions that could be actually spatialized and executed. Therefore, the circular urban systems as proposed in this work can be seen within different levels; at the micro scale a building can be analysed as it is, internally, but it will always be connected to broader systems. From an urban planning/design perspective, the scale of the building, or the architecture of it, is within the most specific case. The Figure 19 presents a notion of the micro and other scales of urban circularity.

Apart from buildings, the micro scale in this diagram takes into consideration individuals and stakeholders. Different from the concept of the circular economy where the micro level relates directly to products and goods that industry and businesses produce and trade, In urban planning the scope of a plan or project does not involve the design or characteristics of such products or goods. However, in a circular city, plans and policies can regulate some aspects of the operation (e.g. mobility, transportation logistics) carried by industrial stakeholders within a city, and those regulations could incentivise the optimisation and localisation of certain resources necessary for the circular delivery of industrial productions and the trade of local economies. At the meso scale, planning and design initiatives in neighbourhoods, city centres and special polygons such as industrial parks could require, for instance, circularity statements and assessments accompanying masterplan and other level of actions. Similarly, at the macro scale, circular strategic thinking should be embedded in policies, citywide and regional plans to tackle broader issues on natural resources, conservations/management of land and future developments.

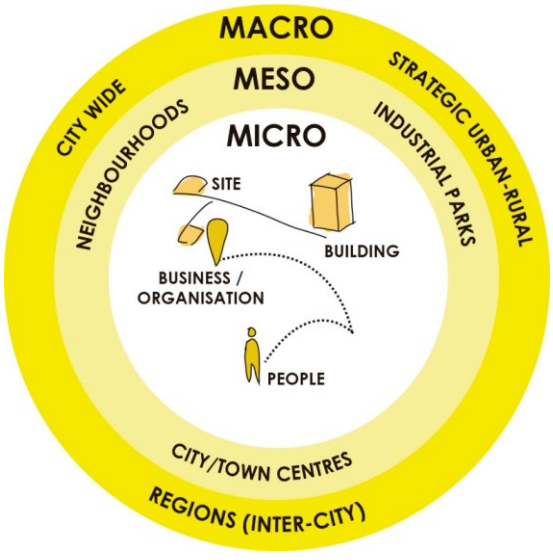


Figure 19. ***The scales of urban circularity***

5.1.2 Key elements of the transition to a circular city

As stated in Chapter 2, the Ellen MacArthur Foundation is currently the principal promoter of the circular economy in the UK and Europe, with premises of (1) Design out waste and pollution, (2) Keeping products and materials in use and (3) regeneration of natural systems (EMF 2015). However, after reviewing other frameworks and guidelines from selected organisations (see appendices) a set of key strategic pillars for the transition to a circular way were identified and grouped by frequency and similarity, considering their potential as basis for the formulation of actions towards a circular city:

- **Bio-Regeneration**
  Aiming to recover resources to the biosphere, reclaim, retain, restore natural ecosystems, wastewater, energy, carbon and other natural resources through conversion, digestion and treatment, considering cost/benefit accounting.
- **Functional Dematerialisation**
  Enabling collective sharing of information and assets through the use of both physical and digital platforms. Promote direct and indirect dematerialisation of products by focusing on the commercialisation of services over products and turning traditional procedures into paperless, remote-basis, data-led etc.
- **Optimisation**
  Increasing performance and efficiency by using better and cleaner technology. Considers predictive actions for maintenance and the extension of the life urban assets, from the conception and design stages of these to the improvement of managerial procedures and regulations (e.g. building codes, incentives) that accompany and support such efforts.
- **Looping and Adaptation**
  Keep components, materials and resources of the assets in a closed loop, both physically (e.g. dismantling and reusing components) and functionally (e.g. changing and adapting use). Recycling, reusing, repurposing, repairing, remanufacturing and refurbishing against underutilisation.
- **Localisation**
  Reinforcing local systems of services, flows and activities (e.g. supply chains) to leverage symbiosis and foster a manageable urban metabolism by localising and spatialising the stock and flows of urban resources to inform decision-making.

- **Collaboration**

  Incentivising synergies between actors. Not all the initiatives need to come from the government, exchange of knowledge and grassroots projects are key catalysts. Also, collaboration can be seen at a large scale (the connections inter-systems i.e. neighbouring cities and regions) and the players at the micro-level (e.g. behavioural change of the population).

The following cross-mapping shows the already described six circularity pillars and their perceived relevance according to the players of urban systems, evaluated through a simple matrix (Table 5) correlating the significance of these pillars to their sensibility in regarding the role of the 7Ps defined in the methodology (the 7th P: Policies is better analysed in the next section as it is strongly attached to the P: Public).

Table 5 ***Matrix of connections between local urban Ps and circularity elements***

SYSTEMS	Resources	6Ps	Bio-Regenerate	Dematerialise	Optimise	Loop/Adapt	Localise	Collaborate	
Emergy, Natural and Built Systems	Raw Materials, Energy, Water	**Planet** (Natural Environment)	High	Low	Medium	Medium	Low	Low	10
	Land and Built assets	**Places** (Built Environment)	Medium	Medium	High	High	Medium	Low	13
Socio-Productive System	People Capital, Food, Goods	**Prosperity** (Economic Model)	High	High	High	High	High	Medium	16
		Private (Businesses activities)	Low	High	High	High	High	High	16
		Public (Local Authority activities)	Medium	Medium	High	High	Medium	High	16
		People (Community activities)	Low	High	Low	Medium	Low	High	11
			12	14	15	16	12	13	

The matrix help to understand how connected are the players, or particular components (Ps) of the local urban systems, to the pillars or elements of a circular city when translating them into urban actions (roles of the players).

In the circularity pillars axis, the category 'Looping and Adapting' seems to be the most versatile at the local scale with a higher potential to be taken into practice since it has high significance/connections to all urban aspects, followed by 'Optimisation'. Similarly, in the urban systems axis (6Ps), the economic sector and activities i.e. 'Prosperity' and 'Businesses' play an important role, followed by the institutional players i.e. 'Local Authorities'.

Overall, the role of these and the characteristics of the built environment i.e. 'Places', combine a big cluster of actionable components towards looping and optimisation all together (dotted line).

From the socio-spatial perspective, whilst the built environment has a transversal role, as a physical scenario where there are many circularity targets (in terms of the use of assets) the community i.e. 'People' column has a stronger significance in 'Collaboration' and supporting elements such as 'Sharing and Virtualisation', because of the direct dialogues within behaviour; i.e. being able to participate and/or embrace dematerialisation (e.g. choosing services over products). Whereas the significance is less for 'Optimisation' for instance, because consumers can directly experience if they are 'Sharing' a product or good instead of owning it, while they can hardly notice or manage if the product/service they paid for was optimised by design in the first place.

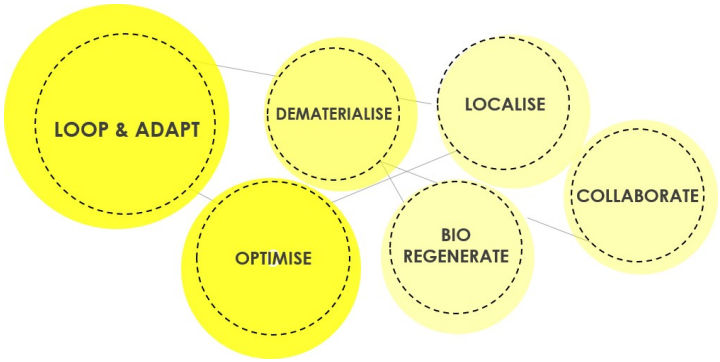


Figure 20. ***The 6 key pillars for the transition to a Circular City by its practicability at the local level.***

5.2 CIRCULARITY IN GLASGOW

As described in Chapter 3, Glasgow has given the first steps towards becoming one of Europe's first circular cities. Thus, this section of the results presents the findings on the connections of the circular economy agenda in Glasgow with other unlabelled initiatives, and the perspective from key actors obtained through interviews and the review of the selected planning policies and strategic documents.

In line with the conceptual framework previously presented at the beginning of this chapter, which illustrated a thematic approach to basic variables of the urban systems from the lens of circularity, some maps are generated to locate 'where' good case practices are taking place in the city to later picture the potentialities of Glasgow as a circular city.

5.2.1 Circular Economy and the race to the sustainability of Glasgow

Following the creation of the 'Sustainable Glasgow' group in 2010, as a permanent partnership, Glasgow's urban and strategic planning initiatives have been aiming at greener approaches involving different aspects of sustainability. Although not all the urban projects, plans and/or strategies that emerged during the period 2010-2020 are labelled as 'sustainable' or 'circular', the review of these and its mapping through the matrix of connections between these initiatives and the key theoretical elements of circularity, show that some of Glasgow's efforts have been supporting 'Collaboration' and 'Optimisation' actions, with 'Localisation' ideas also having a significant presence.

Among the initiatives there are those related to visions and projects aiming to local production of energy, development of technologies and such, like the *Energy and Carbon Masterplan 2014*, *The Resilient Glasgow Strategy 2014*, the *Economic Strategy 2016-2023* - which explicitly consider the circular economy as part of its scope - and most recently, examples such as the *Zero Carbon Communities Programme 2019* and the *Glasgow City of Science and Innovation 2020-2023* which aim to foster knowledge transfer and new practices in manufacturing and low carbon technologies. Also the latest *Park Power Programme* (Greenspace Scotland 2020) that aims to make use of parks and other urban places to localise renewable technologies for immediate energy production within the neighbourhoods.

On the other hand, even though there are initiatives like the *Air Quality Action Plan 2009-2019* that sets some zero-carbon zones where car and bike sharing schemes are promoted or the *Digital Glasgow Strategy 2020* that encourages big data, remote working and other advantages of virtualisation, a lower presence o 'Functional dematerialisation' actions was identified, since fewer initiatives were found in support of sharing economies, digitalisation and service over products premises to reduce consumption and waste generation.

On a similar note, for 'Looping and Adaptation', although already present in older initiatives such as *Stalled Spaces 2011-present* an initiative based on the interim use of available spaces for community entrepreneurship and other local ideas; and the brand new *Property and Land Strategy 2019-2029* – first of its kind in the council – which will guide a better use of the land and buildings in the city, an increasing attention towards 'Looping and Adaptation' can be noticed in newer projects of retrofitting and facilities

like the *Recycling and Renewable Energy Centre (GRREC*) fully operative since 2019 with sections covering energy from waste (EfW).

The updated editions of previous plans like the *City Centre Living Strategy and Vision for 2035* take the circular economy agenda and the reutilisation of resources as one of the drivers for the adaptation of the built environment in this part of the city, while other official documents are currently being drafted with the intention of building more formal foundations and perhaps statutory outputs upon the circular movement as it is already acknowledged that Glasgow is wasting a lot of resources, especially in the construction sector (interviewees from the city council, 2020).

Finally, the official route map for implementing a circular economy in the Glasgow is yet to be approved, but it was stated during the interviews that this is currently being assessed and developed by the *Circular Glasgow Partnership*. The full list of reviewed documents with a qualitative scoring per strategic element can be seen in Table 6 whereas the specific overview of the content per consulted document can be found in one list included in appendices.

NAME OF THE INITIATIVE (LEVERS)	TYPE	SUSTAINABLE DEVELOPMENT ASPECTS				STRATEGIC ELEMENTS FOR THE TRANSITION TO CE					
		People (Wellbeing)	**Prosperity** (Economy/ Growth)	**Planet** (Nature/ Resources)	**Places** (Built Environment/ Infrastructure)	Bio-Regeneration	Functional Dematerialisation	Optimisation	Looping & Adaptation	Localisation	Collaboration
Sustainable Glasgow Board, Since 2010 -ongoing	Board/Parttnership	●	●	●	●	As a aboard it promotes projects and plan on a broad range of aspects					
Air Quality Action Plan 2009 - 2019	Plan/Reports	o		●	o		High	Medium		Low	
Stalled Spaces since 2011 - ongoing / Spaces for Growth	Project/Programme	●	o	o	●	Low	Low		High	Medium	High
Open Data Glasgow	Website/Plaform	o		o	o		Medium	Low			Medium
Understanding Glasgow 2011 - Glasgow Indicators Project	Website/Plaform	●	o	●	o		Medium	Medium		Low	High
Energy and Carbon Masterplan (ECM) 2014	Master Plan	o		●	●	High		High	Medium	High	Medium
Carbon Management Plan, Phase two 2013-2021	Management Plan		o	●	●	High		High	Medium	Low	Low
i Tree Glasgow 2013	Research/Project	o		●	o	Medium				Medium	
Future City Glasgow and Open Glasgow 2013-2018	Project	●	o		●		Medium			Low	High
Resilient Glasgow City Strategy and Framerwork 2014 - ongoing	Framework/Strategy	●	●	o	●		Low	High	Medium	High	High
Waste Strategy Action Plan 2015-2020	Plan/Actions	o		●	●			Medium	Low	Low	Medium
Glasgow City Centre Strategy Action Plan 2014-2019	Strategy/Action	o	o	o	●		Medium	Medium	Low	High	High
Economic Strategy 2016-2023 and Leadership Board	Strategy/ Board	●	●	o	o	Medium	Medium	High	Low	Medium	High
City Development Plan 2017 - ongoing	Plan/Policies	●	●	●	●	High	Low	High	Medium	Medium	High
Strategic Development Plan 2017 - ongoing	Plan/Policies	●	●	●	●	Medium		Medium	Low	Low	High
Connectiong Nature 2017-2022	Project	●		●	●	High		Medium	Medium	Low	Medium
Community Action Plan 2018-2020	Action Plan	●	●		o			Low		High	High
Local Biodiversity Action Plan 2017-2027	Action Plan			●	o	High					Low
Strategic Plan for Cycling 2016-2025	Strategy/Action	o		o	●		Low	Low		Low	High
Housing Strategy 2017-2022	Strategy	●	o		●	Low		Medium		Medium	Medium
Circular Glasgow 2016 - ongoing	Partnership/Agenda	●	●	o	o	medium	Low	High	High	medium	High
Recycling and Renewable Energy Centre (GRREC) 2019 -	Project/Facility		o	o	●	High		Medium	High		
Climate Emergency Working Group 2019 - ongoing	Board/Partnership	o	o	●	o	As group it promotes projects and plan on a broad range of aspects					
Zero Carbon Communities (ZCC) Glasgow 2019-ongoing	Project/Programme	o		●	o	High	Medium	High		Medium	Medium
ParkPower (National Project with city-level Data) 2020	Project	o		●	●	High		High	Medium	High	Medium
Glasgow City of Science and Innovation 2020-2023	Programme	●	●	o	o	Medium	Medium	High	Medium	High	High
Property and Land Strategy 2019-2029	Policy		●	o	●			Medium	High	Low	
Vacant and Derelict Assets Plan 2019-2029	Policy	o	●	o	●				High	Low	Medium
City Centre Living Strategy Vision 2020-2035	Vision/Strategy	●		●	●	Low	Low	High	High	High	High
Digital Glasgow Strategy 2020 - ongoing	Project	●	●	o	o		High	High			High
Open Space Strategy 2020	General Strategy	●		●	●	High		Medium	Medium	High	High

Connection with circularity	Low	Medium	High

Direct	●
Indirect	o

Table 6 ***Urban planning levers of Glasgow versus Sustainability and Circularity aspects***

5.2.2 Stakeholder's views on the circular economy of cities

As an output from the thematic analysis, the Figure 21 compiles keywords and also some rhetoric questions that emerged from the different stakeholders during the conversations on the circular economy concept and its application in Glasgow.

What is Circular Economy?

According to the views obtained, the understanding of the CE concept in Glasgow is based mainly on waste management and recycling strategies as seen from the lens of resource management initiatives applied in industry, with an emphasis on the construction and manufacturing sectors, and business/retail sectors as it presents various opportunities for scaling up processes towards improved business models, with enhanced 'financial benefits' and positive 'structural changes'.

The plethora of concepts that have accompanied the 'sustainable cities' agenda was also mentioned as an issue that some represents a barrier not only for understanding but for engaging others stakeholders with the circular agenda. For practitioners the 'blindness' or 'fuzziness' when talking about CE might produce confusion in whether the use of this concept forms part of or replace regular sustainability targets and visions.

When asked about the processes that could be scaled up, or the structural changes required, most respondents highlighted 'incentives' as one of the top priorities; questions such as '*What would be the motivation of an individual for sharing instead of owning*? along with others questions related to engagement were raised. Secondly, the regulations, monitoring and disclosing processes were found to be relevant because a 'transition needs to be measured and controlled' in order to succeed. Some others mentioned the importance of having funding and proper collaboration for research and knowledge transfer, not only with partners but with other sectors of the community as it could also be one of the means for further incremental engagement.

How is CE translated in Cities?

The most important levers to bring CE to cities, according to most interviewees, were policies and plans, stressing the relevance of those dedicated to the built environment, calling for changes in the construction sector and the planning approach into a more 'flexible' one, functionally speaking. '*Are we building for the future?*' said one of the

stakeholders from the private sector, as a reference on how the construction sector is currently being managed not only in Glasgow but in other cities of the UK, citing particular cases (direct reference edited) where *'It is too easy to demolish'* without taking proper care of construction waste and other embodied impacts. One respondent from the Circular Glasgow team on behalf of the City Council added that 'the amount of material lost is significant in Glasgow' and the way the built environment is managed has an influence on it, but this can be improved by collaborating with developers 'to share data and resources' and the local authority acting as an 'administrator to match up material needs and requests'. Additionally, the retrofitting of buildings and their design under the premises of 'replaceable layers' was also suggested as part of the 'flexibility' required in the design of buildings, These highlighting tnat optimisation does not come from regulations alone, but from engaged developers.

Other stakeholders focused on the context and how the CE in cities needs to take care of what is needed locally. Thus, 'place-based approaches' and 'social aspects' were important to take into consideration in Glasgow, due to the high level of deprivation in many areas, also stressing the relevance of the spatial and social 'Justice' reflected in issues such as fuel poverty, and the ownership-stewardship of assets. Reaching out to all levels of society is seen as an opportunity to support already ongoing initiatives coming from grassroots pilots.

Opportunities and challenges for the transition?

As an advantage it was mentioned that there is some sort of 'backing' from the national level of government in Scotland in promoting the circular switch. Scotland has a national strategy and the local authorities are following the example. One interviewee from Zero Waste Scotland (ZWS) also mentioned that Glasgow, Edinburgh and other cities are currently running different programmes towards circularity. ZWS offers support through funding and knowledge-based guidance, but sometimes is challenging to connect with actors or secure information reaches stakeholders to get the support they offer. In this scenario having a network and proper campaigns are crucial and that is the Chamber of Commerce's leading role.

Among other challenges and general barriers identified, the process of heading from demonstrations of particular groups to mainstreamed ideas is still something that seems far from practical; 'this is mainly because of limitations in terms of budget, the local political will and the structural governance required'; i.e. resistance to change for certain sectors might affect the speed of the transition. Finally, external factors or

threats, specially emphasising the latest pandemic (COVID-19) and how this situation could interfere in the process of adopting the circular agenda was acknowledged. E.g. the re-direction of funding and the uncertainty about a healthy economy amid an upcoming recession could slow down the investment in circular initiatives, but for others, these external threats could actually accentuate the need for sustainable changes and that could impulse the circular transition.

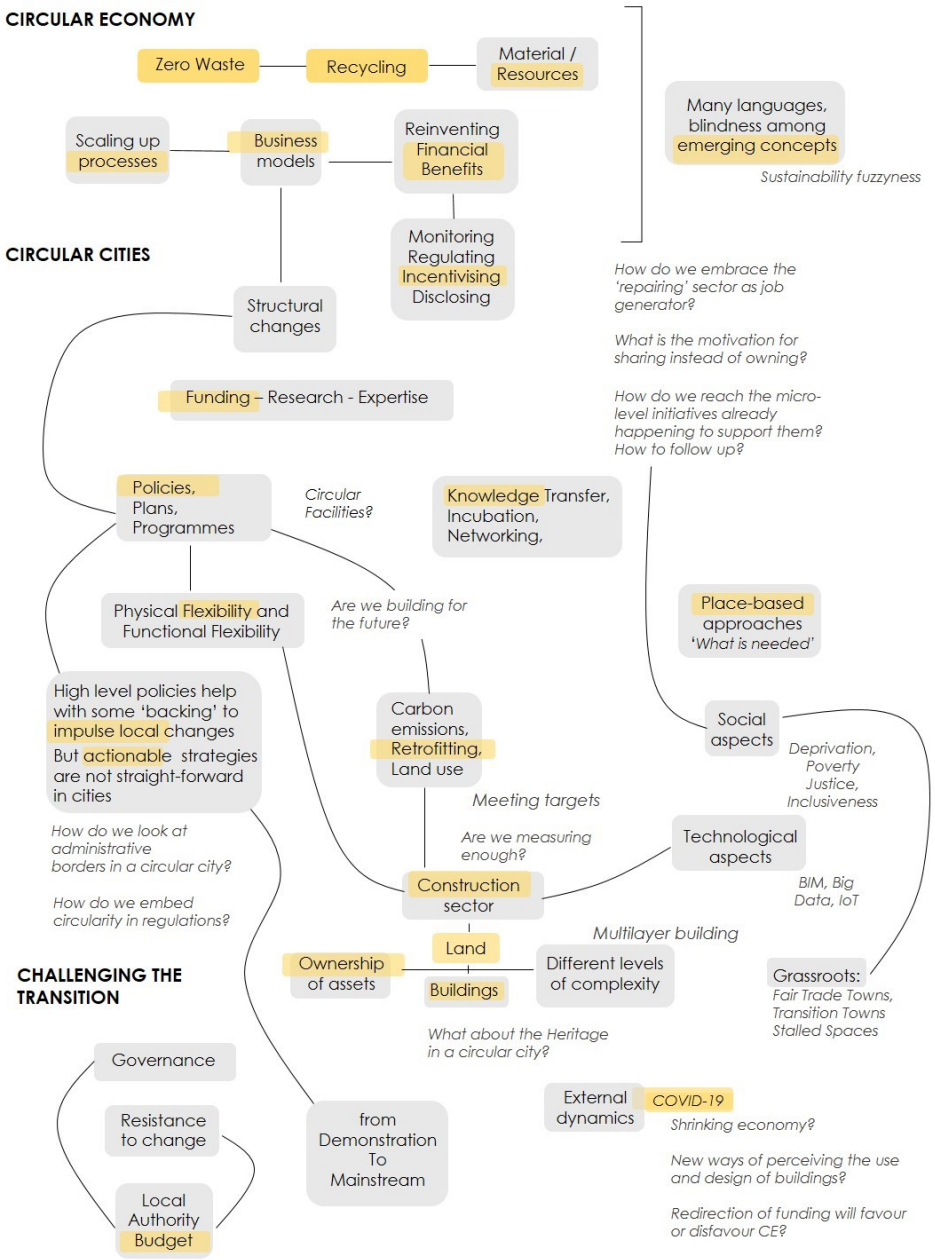


Figure 21. ***Thematic diagram of interviews/conversations with stakeholders.***

5.3 SPATIALISING CIRCULAR VARIABLES AT THE CITY LEVEL.

As mentioned in Chapters 1 and 2, the links between economic planning and spatial planning have always had an intertwined conceptual nexus, but in practice there are silos regarding the different scales and scopes of each field. Furthermore, at the beginning of this chapter, it was identified that when turning circularity into urban practice; the macro, meso and micro scale might differ between a circular economy model (CEM) and a circular city model (CCM). Thus, this section focuses on the spatialisation of some variables within the urban systems of the city of Glasgow for which basic data frames were available, and served to estimate certain conditions that might play a role in its circular transition.

5.3.1 Built and property systems

To make the built and property systems more circular, there must be a proper management of these assets. Therefore, the assessment of certain characteristics of spaces and buildings i.e. in terms of design, construction and adaptation, as well as the localisation of good-case practices in the management of them, are among the variables that must be taken into account.

5.3.1.1 Estimation of the material stock in buildings.

Glasgow has around 48,9 million tonnes of materials according to the sample modelled, covering around 90% of the buildings in the city[11]. The distribution of these materials is shown in the Figure 22 in which the City Centre, some parts of the West End (Hillhead, Woodlands, Hyndland, Partick East, Dowanhill), and the Southside (Langside and Battlefield) concentrate the highest amount of material. The City Centre alone has approximately 7 million tonnes of material in buildings (14,3% of the total) with cells (300x300m) containing up to 430 thousand tonnes of material per each 9 hectares of urban surface.

[11] The main sample is composed of buildings that were classified as residential and commercial (Offices + Retail + some Facilities). Among the 10% that were not considered there are industrial, unclassified, petrol stations, manufacturing and some mixed buildings. It is also important to note that infrastructures (road networks, electricity and other utility networks) are out of both the 90% and 10% percent mentioned. Please refer to the methodology for more details.

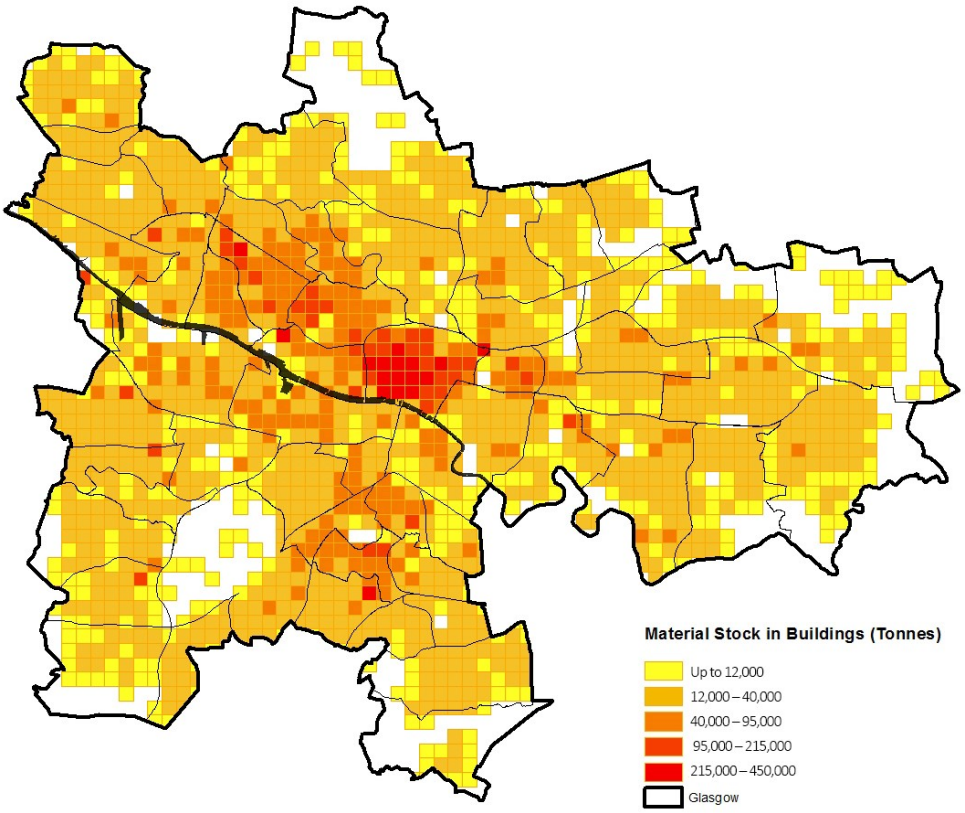


Figure 22. ***Material stock in buildings of the city of Glasgow***

When zooming in the area surrounding the River Clyde (Figure 23) a detailed view of the buildings accounting of more material density shows that, although scattered, there are some evident clusters alongside the river and its southern part. On the other hand, it is important to mention that this estimation is not differentiating between structural and non-structural materials, but it serves to visualise where the building stock could potentially be managed as an urban mine in the long term.

Furthermore, the specific maps for each type of material considered as parts of the material content analysis presented in the Figure 24, makes visible that the highest amount of some types of materials are not always in the centre, for instance; steel and glass are more prominent in the City Centre, whereas copper and aluminium are clustered both in the City Centre and some areas of the West End (this is because of the diversity of typologies and functions). In contrast, concrete and wood are spread throughout the city, being this last material the one with the most uniform distribution but not the most prominent. The top 3 contributors of the material stock estimated in buildings by amount (tonnes) are concrete, followed by steel and wood.

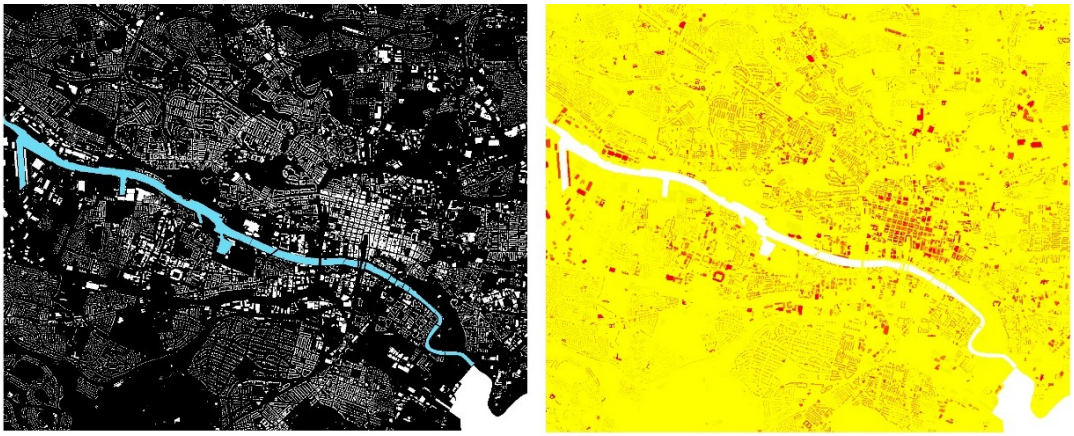
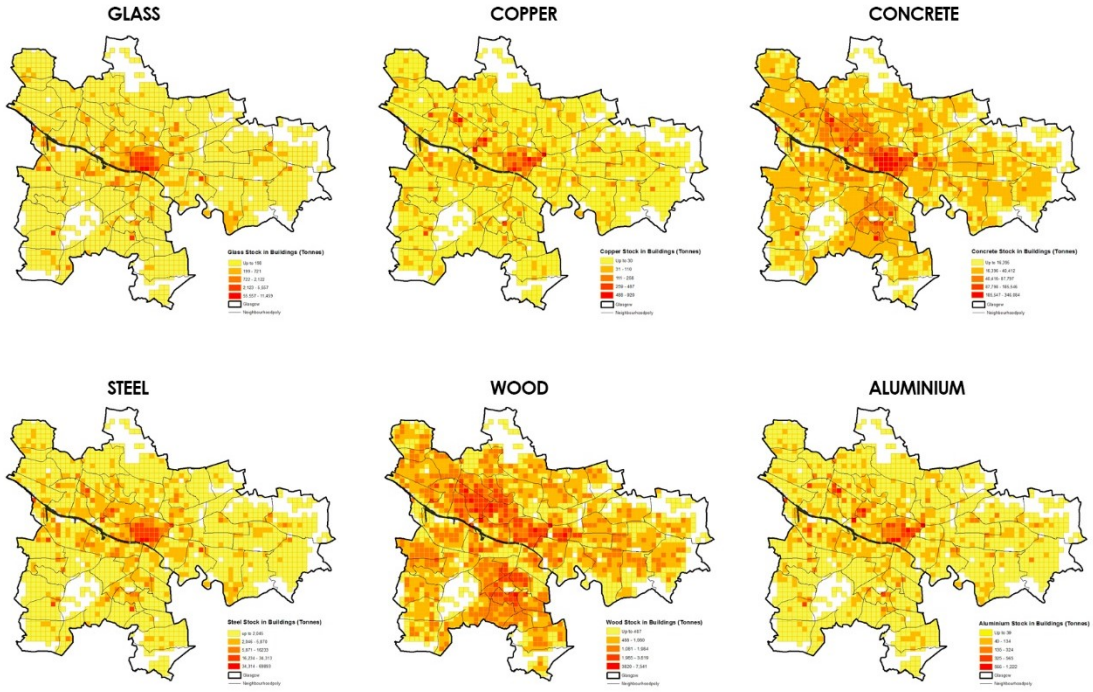


Figure 23. ***Zoom in to the material in buildings around the River Clyde area***

In average, there are 280 tonnes of material per building, this varies according not only to the size but the type and use of the edification, also according to the types of materials considered in the model (this model is not exhaustive). It is important to mention that the maps in Figure 24 are not presented with the same range of values, so although useful for comparing the spatial distribution of materials, these are not suitable for a visual comparison on quantities between the different materials (see bottom).



(tonnes)	Concrete	Wood	Copper	Aluminium	Steel	Glass	Total Overall
Total per type	43,733,469	1,460,762	46,782	61,863	3,327,818	348,664	48,979,358
Average per Building	250	8	0,27	0,35	19	2	280

Figure 24. ***Spatial distribution of material by type of material in the built stock of Glasgow.***

5.3.1.2 Wastescapes

Glasgow City has a well-known amount of WS1: vacant and derelict land (VDL). The city alone contains 9% of this type of wastescape[12] in Scotland - the largest area of the Local Authorities - with 954 hectares declared in 2019 (Scottish Government 2019). According to the latest register available and used for this project (Ordnance Survey, January 2020), this sums up to 1007 hectares, with 460 hectares (45.6% of the total) being of public property. The number of non-residential buildings in the city that were found to be vacant derelict and/or at risk (VDB), which defines the second type of wastescape in this project (WS2) reaches 440 units. But, a recent report by Glasgow City Heritage Trust identified around 2,600 long-term empty homes in 2018 and circa 1,000 empty commercial and industrial premises in Glasgow (GCHT 2019).

Apart from the VDL and VDB, the third type of wastescape considered as WS3: 'Dross from infrastructures', which mostly accompanies highways and junctions and do not provide an actual use or service, represents around 828 hectares of areas that could be better used for a more productive purpose. Some of this Dross is categorised as 'Green Corridors' in the OS Green Space maps, but in practice they are mostly underutilised grassland.

The map of the spatial distribution of wastescapes by density (Figure 25) shows the distribution of these spaces in the city; some clusters of one predominant type, and others combining the three types of wastescapes are highlighted in warmer colours. The red cells are where more wastescapes can be found per each 9 hectares of urban surface. In general, the density is higher around different areas to the north (Lambhill, Milton, Ruchill, Possilpark, Robroyston and Millerston) with a similar significant presence in the south side of the City Centre (Este Kingston – Tradeston and the Gorbals) and some scattered presence within other neighbourhoods.

[12] Term to refer to brownfield and other spaces that result of operational and infrastructural waste, or functional underutilisation. Please refer to the methodology, Chapter 4 for more details.

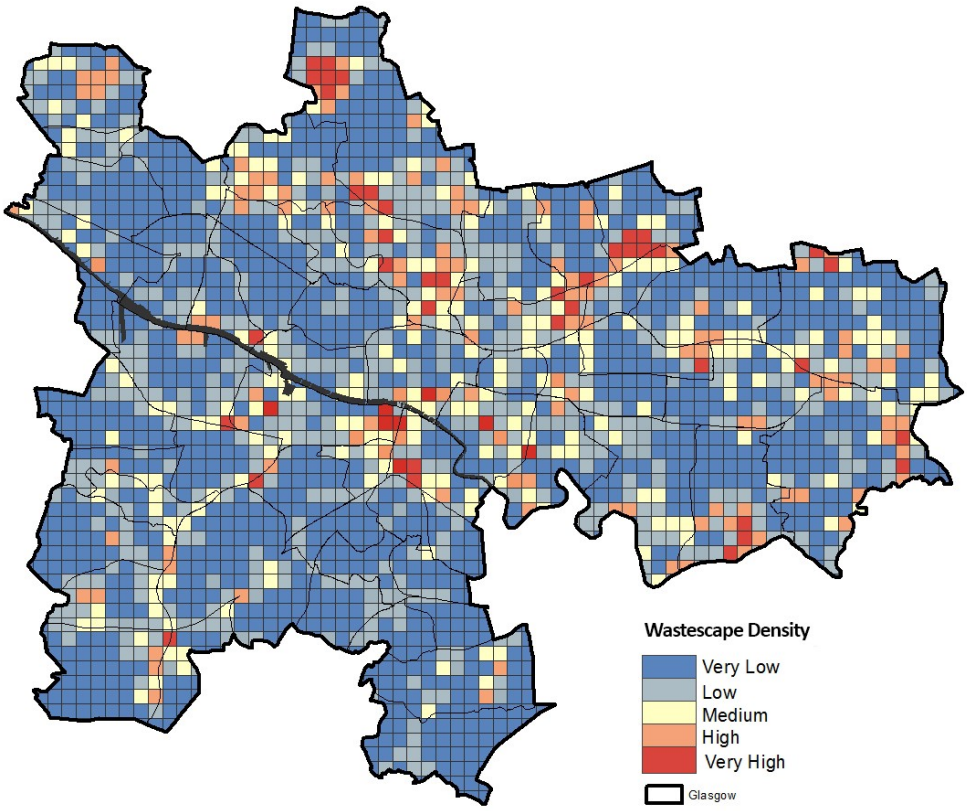


Figure 25. ***Spatial distribution of wastescapes in Glasgow.***

When comparing the distribution by specific types of wastescape, a more detailed idea of the patterns can be observed (Figure 26). Most large areas of WS1: VDL are located to the north, whereas in the central part, specially alongside the river, the amount of WS2: VDB, are highly accumulated. The distribution of WS3: Dross from infrastructure is more scattered, but linearly patterned as it follows the main connections of the main roads network. Overall, the centre and north are the areas of Glasgow that demand more attention in regard of wastescapes management.

In the same Figure, a sample of one of the main clusters can be better observed (Southside of the City Centre, between Kinning Park and Laurieston). This zoomed view gives a closer spatial reference of the problem in areas where the presence of the three types of wastescape is highly significant.

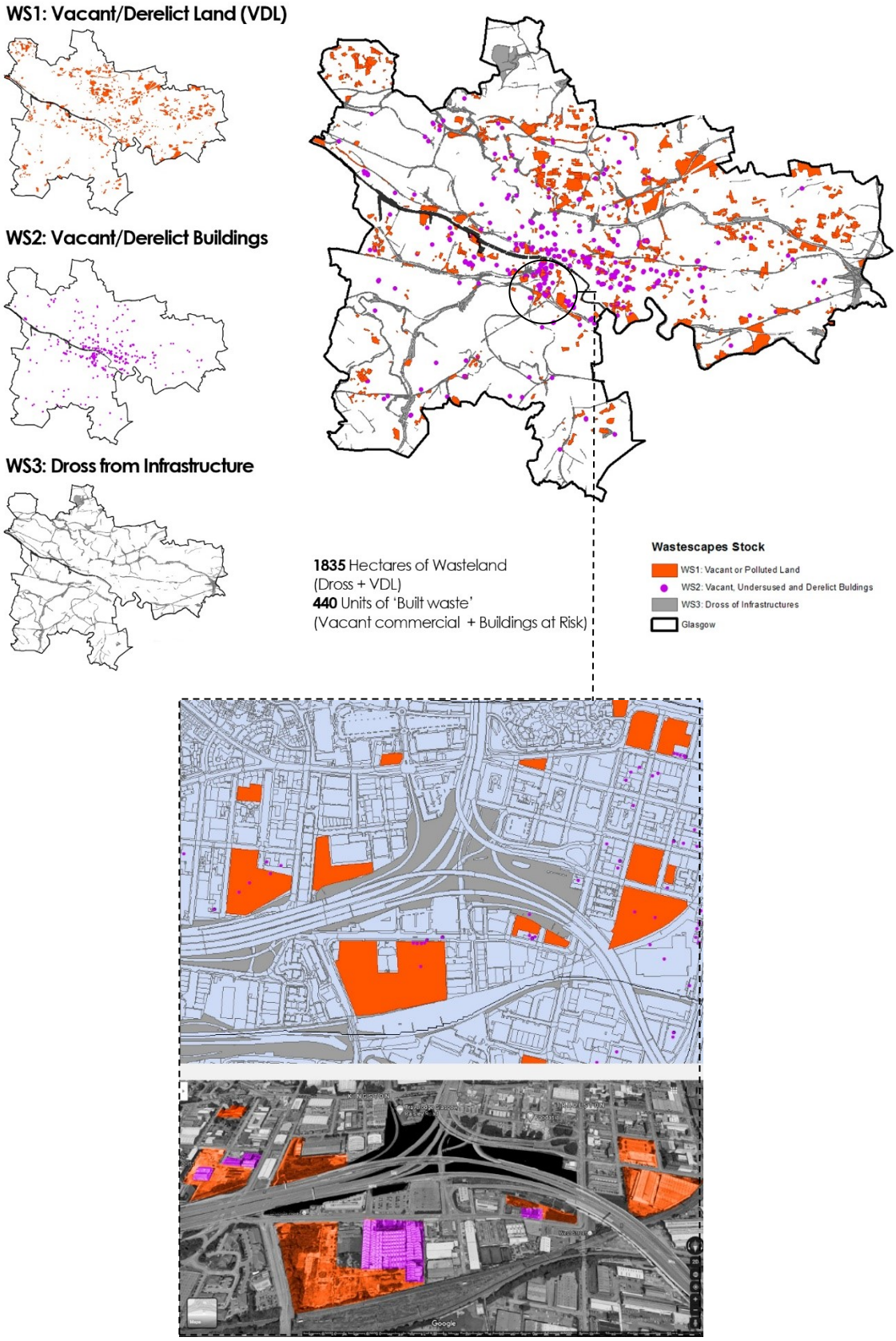


Figure 26. ***Three types of wastescapes (top) and zoom in to one hot spot or cluster (bottom)***

5.3.1.3 Recycled land and built assets

Most studies focus on the presence of VDL and its influence, but from the lens of circularity it is also important to identify good-case practices. Glasgow has had initiatives to overcome the management of dereliction, one of those is the *Stalled Spaces* Scheme through which more than 100 initiatives have made interim use of the vacant land in the city. In addition to this, some public and private stakeholders have repurposed buildings, turning them into versatile and productive uses, 18 examples were identified and mapped alongside the tactical urbanism initiatives of *Stalled Spaces* in the Figure 27 to get an idea of where these forms of circular management of assets have taken place. Additionally, an overlaid background of the concentration of wastescapes helps the reader to visualise the dynamics i.e. activation and de-activation of these spatial assets. The presence of more changes or practices are seen around the geographical centre.

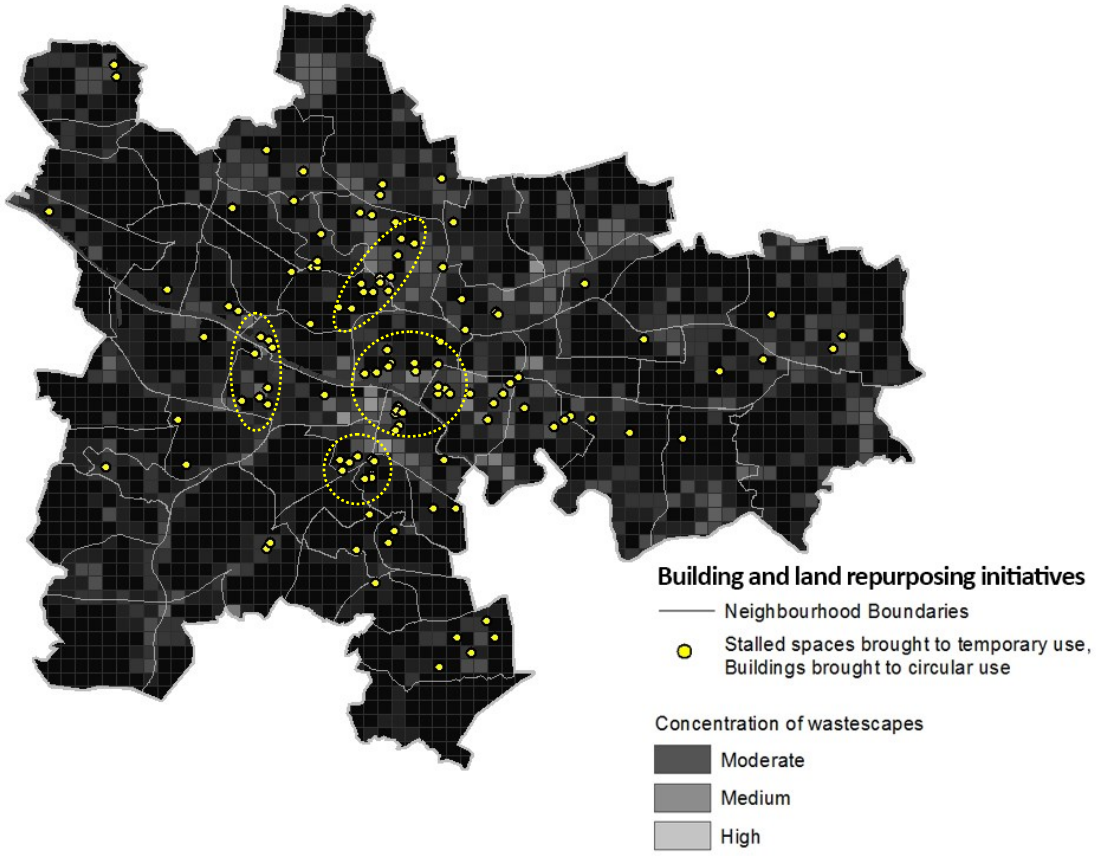


Figure 27. ***Spatial dynamics between activation and de-activation of land and built assets.***

Most of the interim uses of land since 2011 have been in the form of community gardens, local events, and commercial pop-ups and local dynamics (GCC), whereas the repurposed buildings identified have taken a variety of original ad-hoc designs (churches, industrial and commercial warehouses, tenements and so on) to turn them into creative venues, flexible and serviced spaces. A List of the example of building repurposing is shown in Table 7.

Table 7 ***Sample of repurposed buildings***

Place	Old use	Repurposed as
Saint Luke's & The Winged Ox	Church	Venue
Oran mor	Church	Bar-Theatre
Big Feed, Govan Road	Warehouse	Food Market
Old Fruitmarket	Market	Venue
Barras Art and Design	Market	Multi-use creative industry units
The Engine Works	Industrial	Multifunctional space
The Clydeside Distillery	Distillery	Distillery (Reburbished)
The Whisky Bond	Bonded Warehouse	Creative Studios and Workspaces
69 Buchanan St	Old office	Serviced office centre and facilities
100 West George St	Old office	Commercial and serviced offices
1 West Regent St	Old office	Oficces and 1 level of open flexibe space
Collabor8te	Old Tenement	Shared Co-Working spaces
Glasgow Collective	Industrial-Commercial	Shared Co-Working spaces
RookieOven	Industrial-Commercial	Serviced office spaces
Dovehill Studios	Industrial	Multifunctional space
Tramway	Depot and Workshops	Art Gallery and Creative Spaces
SWG3	Industry - Warehouses	Multifunctional Creative Venue
Briggait Spaces	Fish Market	Art Center

5.3.2 Socio-productive systems

The dynamics between different sectors of the community and the patterns of local economies are one of the most important drivers of circularity. The diversity of commercial activities, community engagement, entrepreneurship, among other business related aspects are illustrated through the following data mapped in Glasgow.

5.3.2.1 Distribution of circular businesses

It was identified that Glasgow has a total of 12,845 commercial services and retails of which circa 6% percent could be considered circular according to selected core categories, the sample identified through the datasheet used i.e. the last update of the

'*Point of Interest*' by Ordnance Survey in March 2020. Similarly, in terms of circular jobs; 21,000 out of 375,000 jobs - a share of 6% - was found by Circle Economy and Erasmus University (Circular Glasgow Partnership) to be circular with activities involving repair, leasing, and waste management in the manufacturing, digital technology, engineering, design and creative industries. Within the quota of 6% of 'circular jobs', 37% follow core circular strategies, whereas the rest of 63% are classified as enablers and indirectly circular. (Circle Economy 2018)

The spatial distribution of the circular business identified in this project (commercial services and retails) is shown in Figure 28. This map showcases its presence following a horizontal axis alongside the River Clyde: West- Centre- East, specially clustered around the main streets of Partick, St. Enoch, Dennistoun and Govanhill. In the map at the bottom right, the overlap of circular businesses (yellow dots) on regular businesses (grey dots) show the general spatial concentration of commercial and retail activities in the city. It can be observed that the city centre is fully highlighted in the map, also showing that there is a scattered distribution around the city, which relates to the presence of mixed uses.

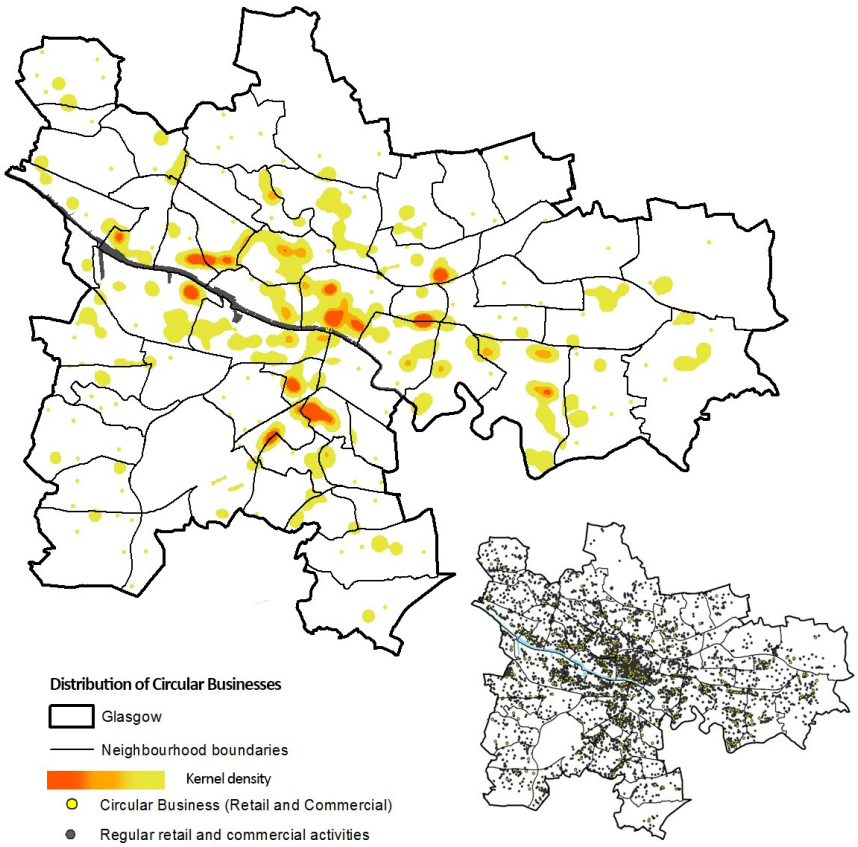


Figure 28. ***Distribution of circular activities in Glasgow***

Besides the spatial distribution, it is important to know the functional characteristics of these circular businesses. Thus, when grouping, by frequency, similar categories (Figure 29) a predominance of farm shops and 'pick your own' type of businesses represents the 20.4% of the sample. Charities and Second-Hand Stores combine around 13.7%, those offering electrical equipment repair and servicing 12.2% and clothing/shoes repair, fitting or hiring form the 11.2% of the sample.

Second-hand vehicle sales and rental represent 14.6% of the businesses; but the circularity of this category might be questionable. On the other hand, gardening, construction, household and industrial goods repair form all together around 17% of the offer.

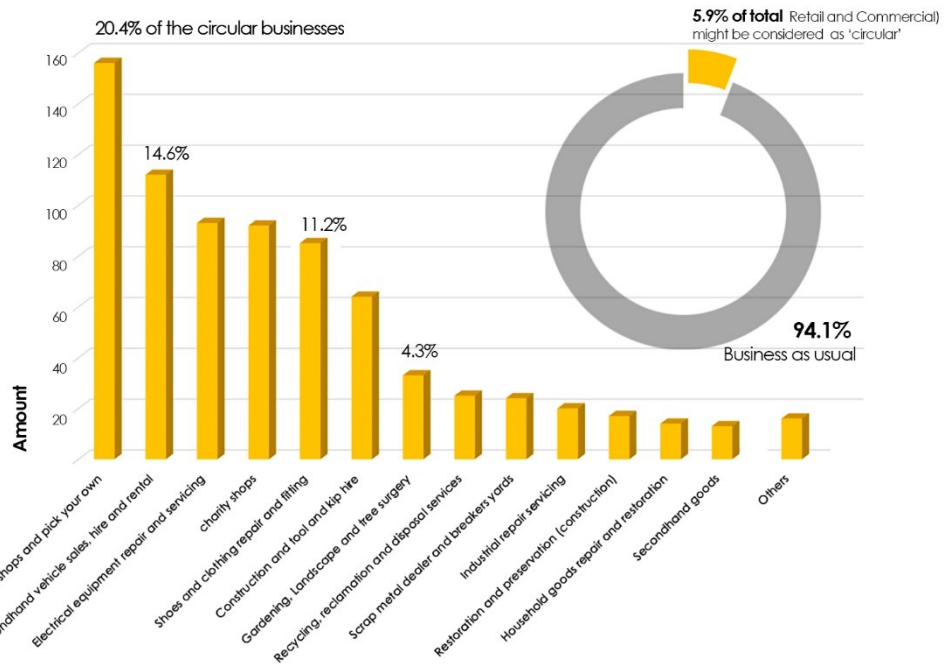


Figure 29. ***Glasgow's circular activities in the commercial and retail sector, by category.***

The full list of categories considered can be found in the appendices of this document. Overall there are good practices that could be scaled up because of their impact on other types of businesses, such as the ones related to manufacture of sustainable packaging, which currently represent a very low share. In addition to this, there are private commercial services that support some public facilities by offering waste recycling, reclamation and disposal activities, 26 units of this type were found in the city, a share of 3.3% of the total circular businesses identified.

5.3.2.2 Distribution of community levers and social capital

There are characteristics of the population, and the community facilities, that could help with the engagement and collaboration processes that a circular society demands. In Glasgow there are currently 132 Halls and Community Centres and 38 Community Networks and Organisations that conform 171 public facilities available to general groups. Altogether these facilities represent a fair spatial offer across different neighbourhoods, located within walkable distances. On the other hand, when checking the availability of other facilities to encourage public communication such as Wi-Fi spots, these last are more concentrated in the central area, leaving uncovered zones to the north, east end and southwest as can be observed in the Figure 30.

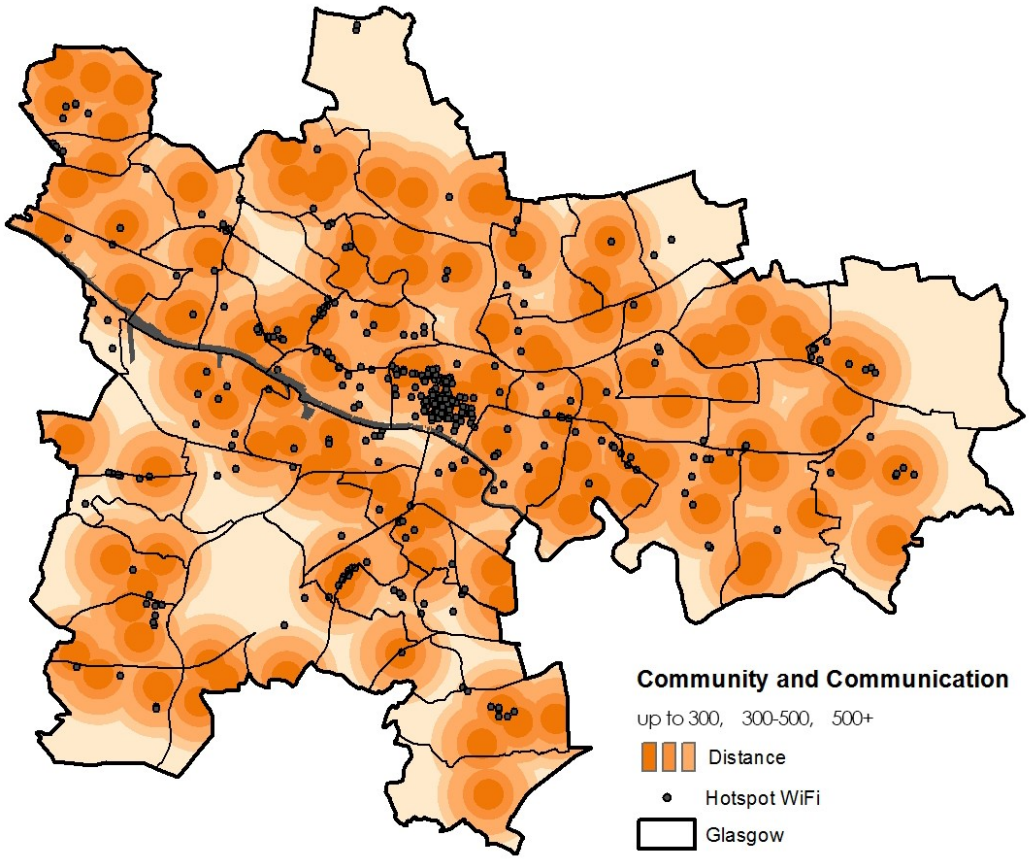


Figure 30. ***Stock of community levers in Glasgow***

In terms of population characteristics, a generalised idea of social capital was mapped (Figure 31) by integrating two variables: the level of participation in recent calls of the initiative Open Glasgow (top right corner) and the share of population that declared

being small employers and entrepreneurs according to a survey conducted under the Understanding Glasgow's Project (bottom right corner). Overall, the social capital measured through these two variables seems to be theoretically greater outside the city centre, especially to the Southside and Northwest.

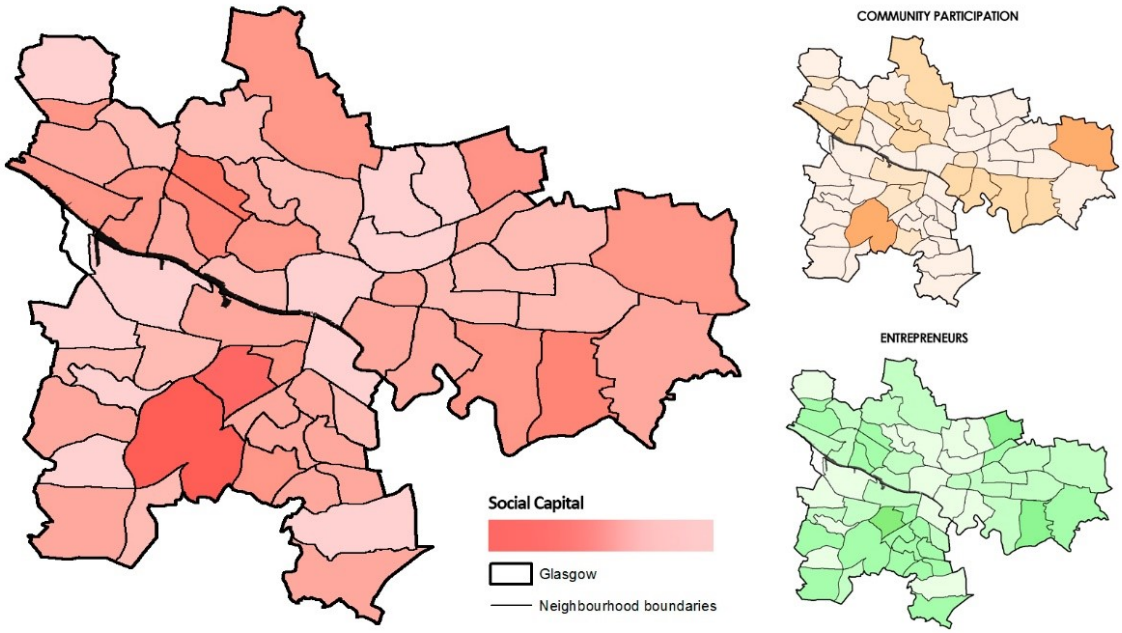


Figure 31. ***Theoretical approach to social capital in Glasgow***

5.3.2.3 Distribution of public facilities for waste recycling

There are 368 publics recycling bins around the city. The most served areas are the north part of the City Centre, Dennistoun, part of the West-End (Hillhead and Woodlands) and part of the southside (Shawlands, Langside and Govanhill). Apart from paper, cardboard, plastics and the typical waste streams collected from households, these public bins include some other types that are not covered in the regular household collection; such as mixed glass and, in some particular cases, textiles and waste oils.

The relevance of the location of these sites relies on their proximity within walkable distances, which can also be observed in the Figure 32, which makes evident that the southwest and the broader north and east-end are the least served areas.

Currently, only 26% of the household waste is recycled, the rest of the waste generated ends in landfills and other unsustainable processing, leading to a Carbon Impact of 1.17 TCO2e per person (SEPA 2019). During the period 2011-2018 there has been an increase in the recycling of glass and plastics, with a small decrease in paper and cardboard.

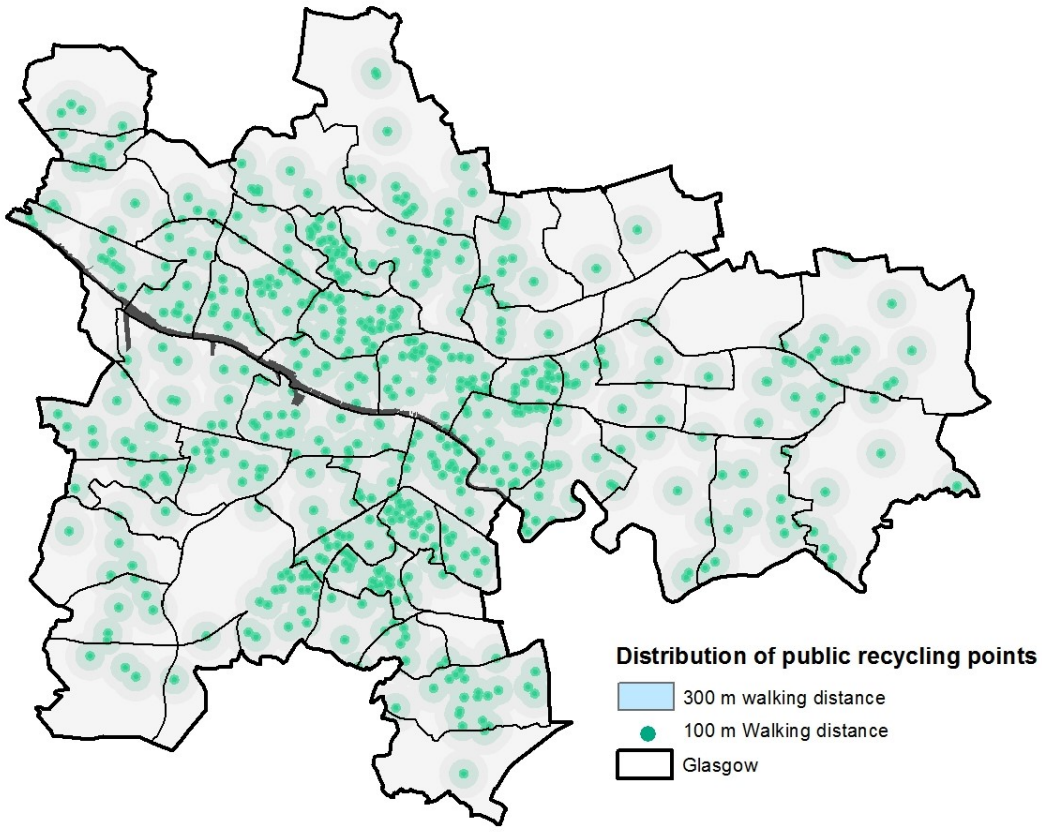


Figure 32. ***Spatial distribution of recycling points and their coverage in Glasgow***

5.3.3 Emergy and mobility systems

The grey infrastructure provides the necessary networks for main utilities and services to reach regular urban functions. Thus, the way it is designed or distributed can enable or hinder the implementation of a sustainable and circular metabolism in the city. In this section, some variables related to energy and transportation are mapped to get an overview of the spatial conditions that support consumption and production patterns in Glasgow, and the potential theoretical emissions seen through its mobility settings.

Even though this project's aim is not focused on energy or emission accounting, it is conceptually relevant to provide a context from a spatial perspective.

5.3.3.1 Facilities for sustainable mobility.

As can be seen in the Figure 33, the current facilities that encourage sustainable mobility, such as bike rental points, charging points for electric cars, and places to hire a car when needed (instead of owning it), are clustered mainly in the city centre and its immediate area of influence. Consequently, the rest of the city has poor accessibility to these options (Top image). In contrast, overlap this dataset with the declared walking and driving patterns obtained in the survey of the Understanding Glasgow Project, it can be seen that in neighbourhoods of the central area the share of people that prefers walking or cycling as a mean of transportation is greater (bottom right). Whereas the share of households that declared to own/drive two or more cars is higher around the city boundaries (Bottom left).

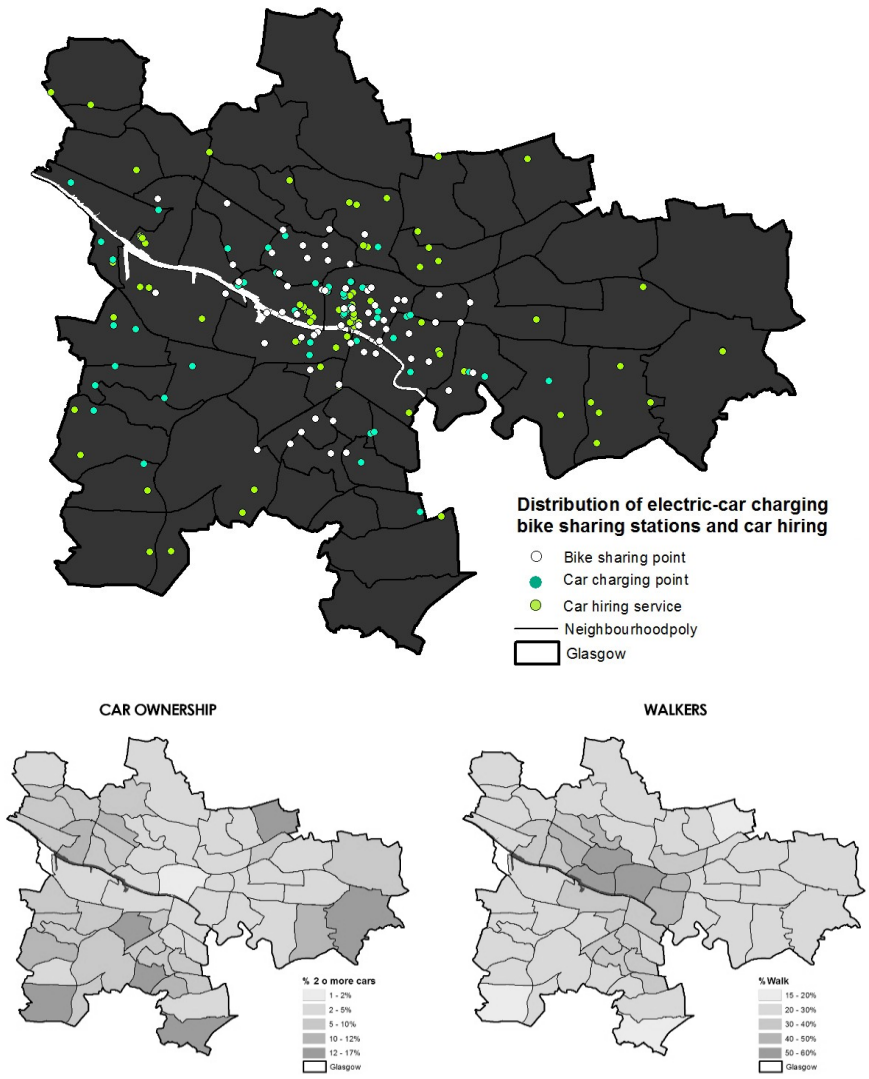


Figure 33. ***Spatial distribution of alternative mobility levers and mobility choices.***

Apart from the shared services provided or the mobility choices of the population, the physical characteristics of the street networks and its relation with pedestrianised means is illustrated in the Figure 34. The share of pedestrianised surfaces compared with vehicle-oriented surfaces varies around the city. The street network favouring vehicle tends to be that around the main roads and highways (red cells), but in general most neighbourhoods tend to have 40-60% or pedestrian space against road spaces (Yellow cells). Overall in Glasgow there are 31 Sqm/cap. of roads, 25 Sqm/cap of sidewalks or pedestrianised civic areas and 11 Sqm/cap of green spaces (excluding private green areas and non-equipped green areas e.g. grasslands without formal footpaths).

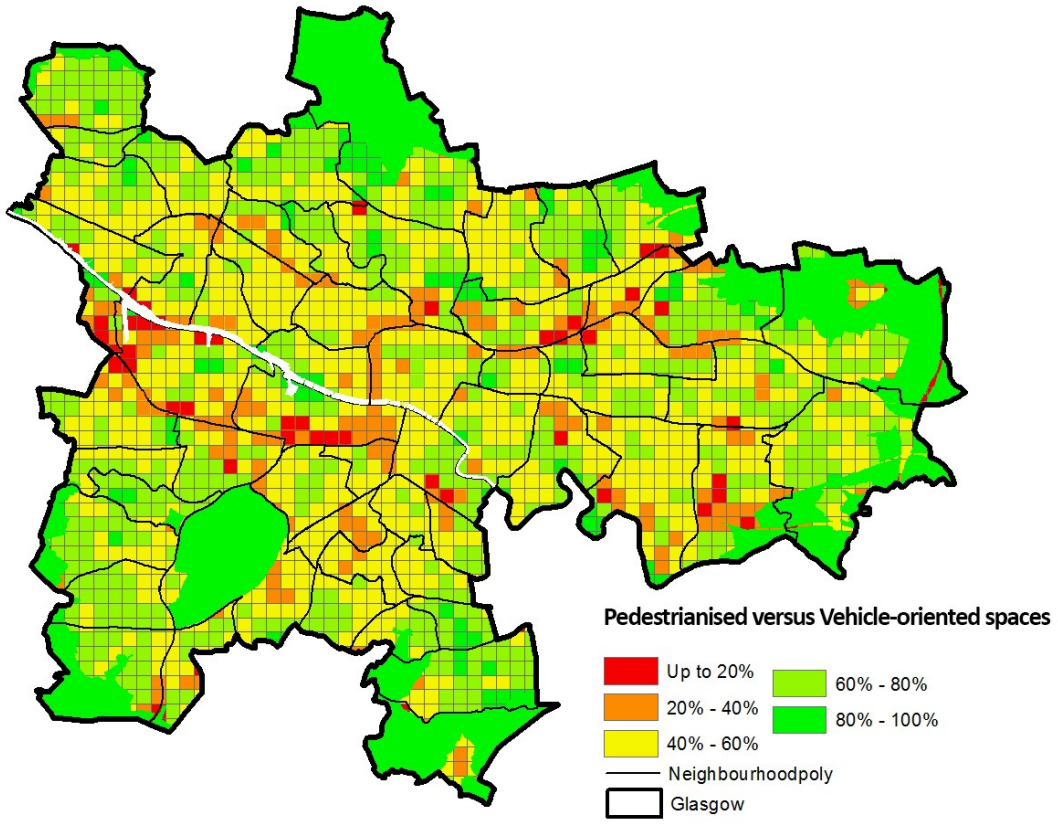


Figure 34. ***Pedestrianised versus car-oriented physical structures in Glasgow.***

5.3.3.2 Renewable technologies

There have been many initiatives in terms of energy technologies in Glasgow, the *Carbon and Energy Plan 2014* provides information about the projects that are taking place and their expected outcomes. Glasgow has envisioned district heating projects going along with retrofitting of the building stock to improve their energy efficiency.

Similarly, some studies commissioned by institutional partnerships have assessed the potentialities of the implementation of renewable energies across the city, from geothermal to PV panels allocation (Strathclyde University; Scottish Energy; etc), and in practice, there are examples of housing associations installing some of these alternatives in their residential units. In the figure below a visual summary is provided to observe where these actions and visions are intended or happening already.

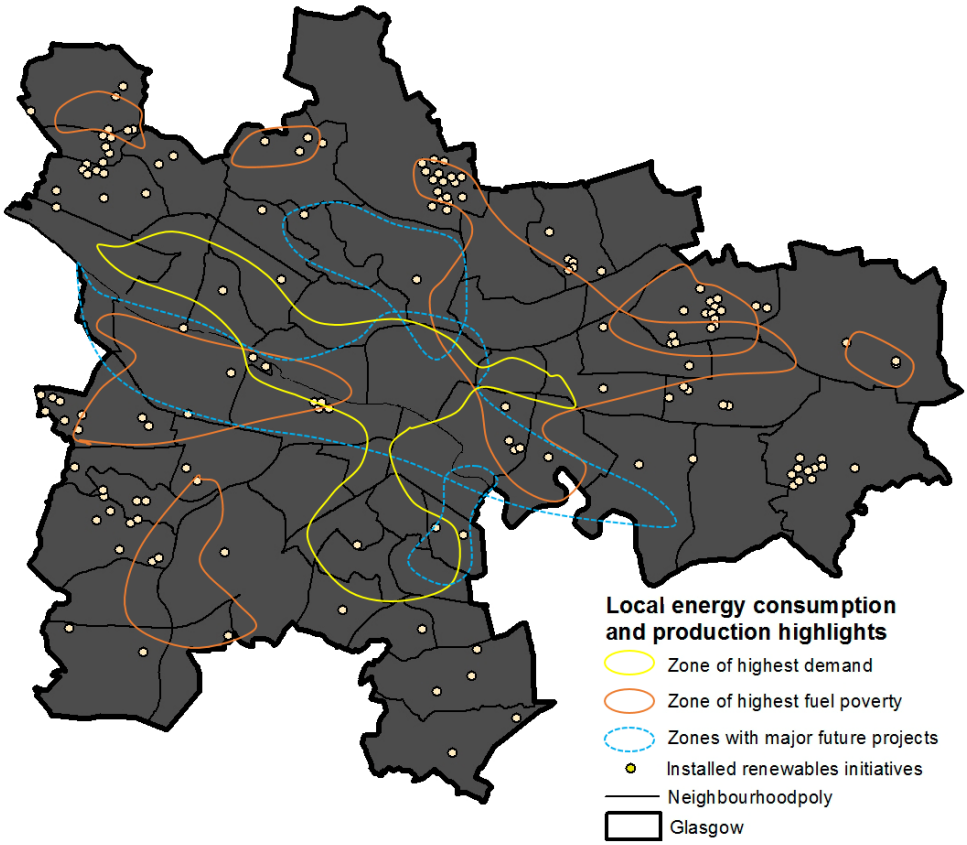


Figure 35. ***Spatial distribution of renewable energy initiatives in Glasgow.***

5.3.4 Natural and Ecological systems

5.3.4.1 Green and blue surfaces

When taking into account all the natural landscape, without classifications, Glasgow's greenery can reach up to 10,420 hectares. But a significant amount of these areas corresponds to private gardens or areas that do not offer a place for the public

enjoyment; e.g. plain grasslands or the dross space from infrastructure that, although green, it does not offer either ecosystem services nor alternatives for communities to transit or stay. However, the spaces these functions and amenities; meaning parks and equipped green areas, group around 70.4 hectares in the city (Figure 36).

Park Power (Greenspace Scotland 2020), a recent project that intends to make the most of parks and watercourses to decarbonise the energy production systems in Scotland, classifies parks according to its size, location, and other conditions to determine its suitability to generate an actual benefit for the surrounding buildings in terms of energy provision and ecosystems services. In general, there seems to be an extended theoretical opportunity to serve different areas of the city of Glasgow through these settings of green areas. However, areas in the city centre and neighbourhoods alongside the River Clyde are less likely to be benefited from greenery.

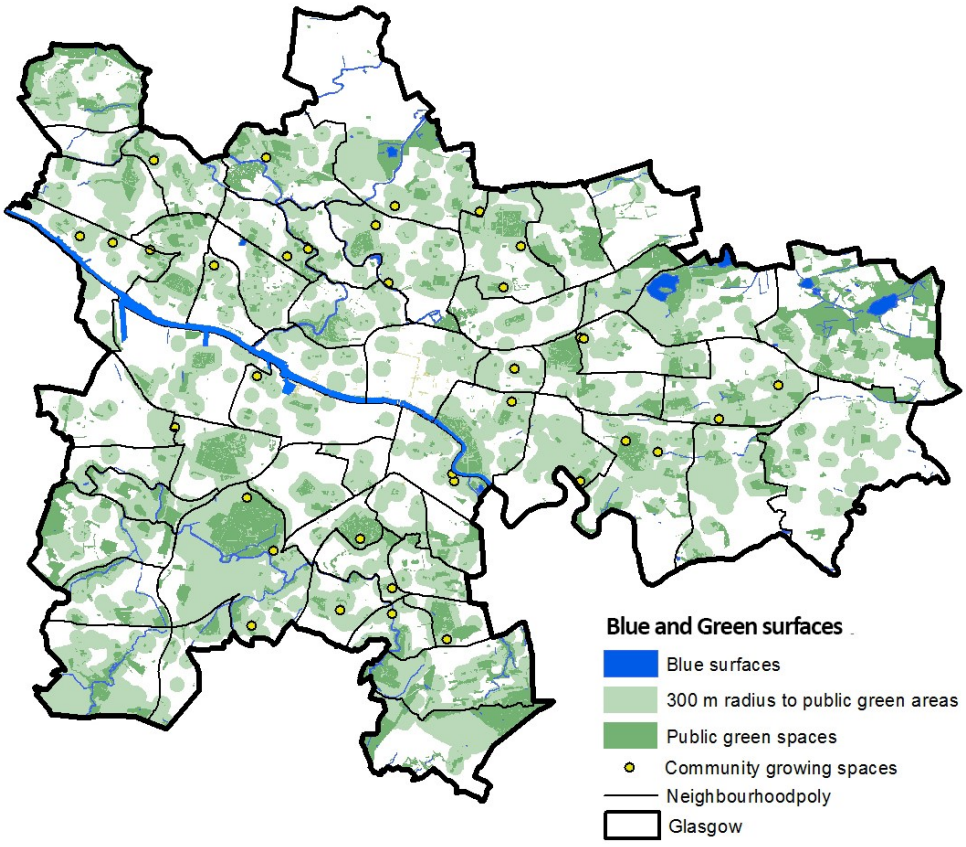


Figure 36. ***Spatial distribution of blue and green surfaces in Glasgow.***

Apart from the potential of parks, there are green spaces in the city that labelled as allotments (Yellow points on the map) and contribute to local functions of urban growing spaces, community gardens and other sort of spaces that enhance the

diversity of usable green areas. Currently there are 35 allotments around the city that together with other community gardens identified, form an offer of around 45 spaces for local food growing.

5.4 CIRCULARITY POTENTIAL AT THE MESO SCALE (NEIGHBOURHOODS)

After mapping all the variables for which data was reliable, a selection of metrics was considered for illustrating the circularity potential of Glasgow in terms of a group of practices that contribute to the path towards a circular performance. Even though it cannot be taken as a full circularity performance measurement as to it does not consider all the dimensions of circularity and metabolic flows, the following map (Figure 37) portrays the results by neighbourhood focused on the accounting of socio-spatial aspects (stocks). The areas of Calton, Bridgeton, Hilldhead, Woodlands, Ruchill and PossilPark have the highest mean score, followed by areas around the centre and south of the city. Note that the highest mean scores are still within medium to low scores (circa 2 points out of 4) in the scale described in the methodology. Thus, the 'circular' performance of Glasgow is still very low overall but with multiple opportunities.

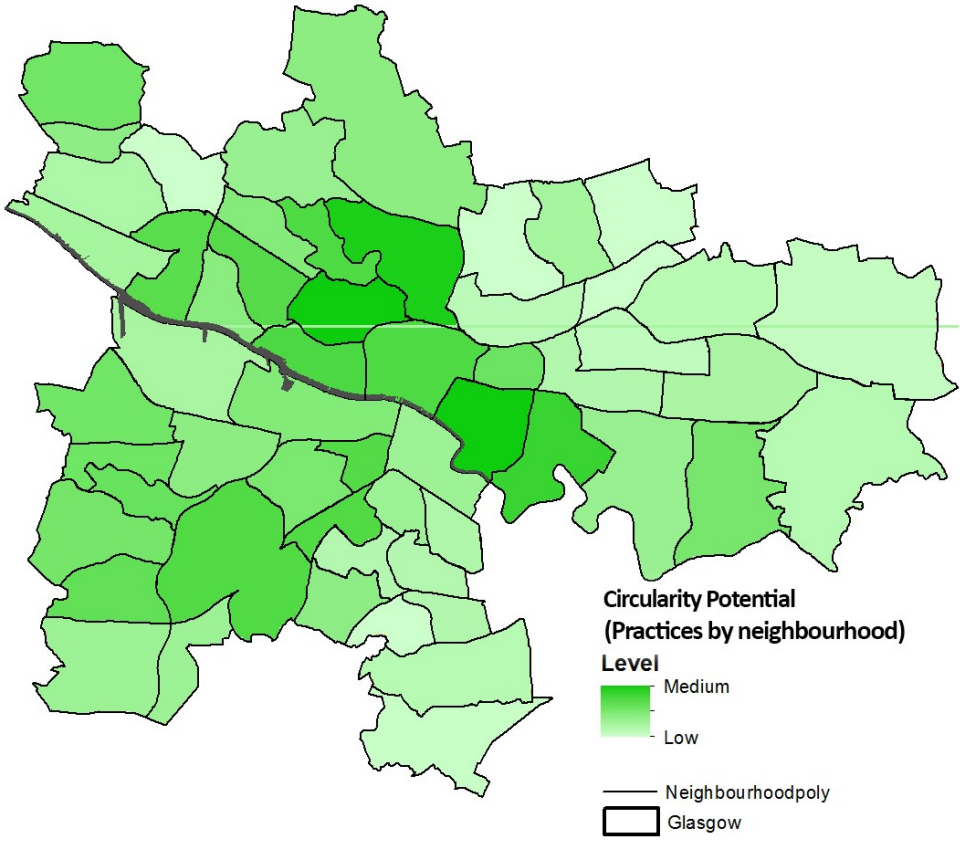


Figure 37. ***Circularity potential by neighbourhood in Glasgow***

The previous map shows the zonal mean of the results obtained from the multi-criteria weighted analysis. Similarly, the Figure 38 shows in more detail which areas within the neighbourhoods are better scored, so that a closer look (Figure 39) to the spatial distribution of these scores serves to better understand the results in terms of the specific areas that contribute the most or, on the contrary, demand more planning and design attention towards the implementation and monitoring of circular urban practices.

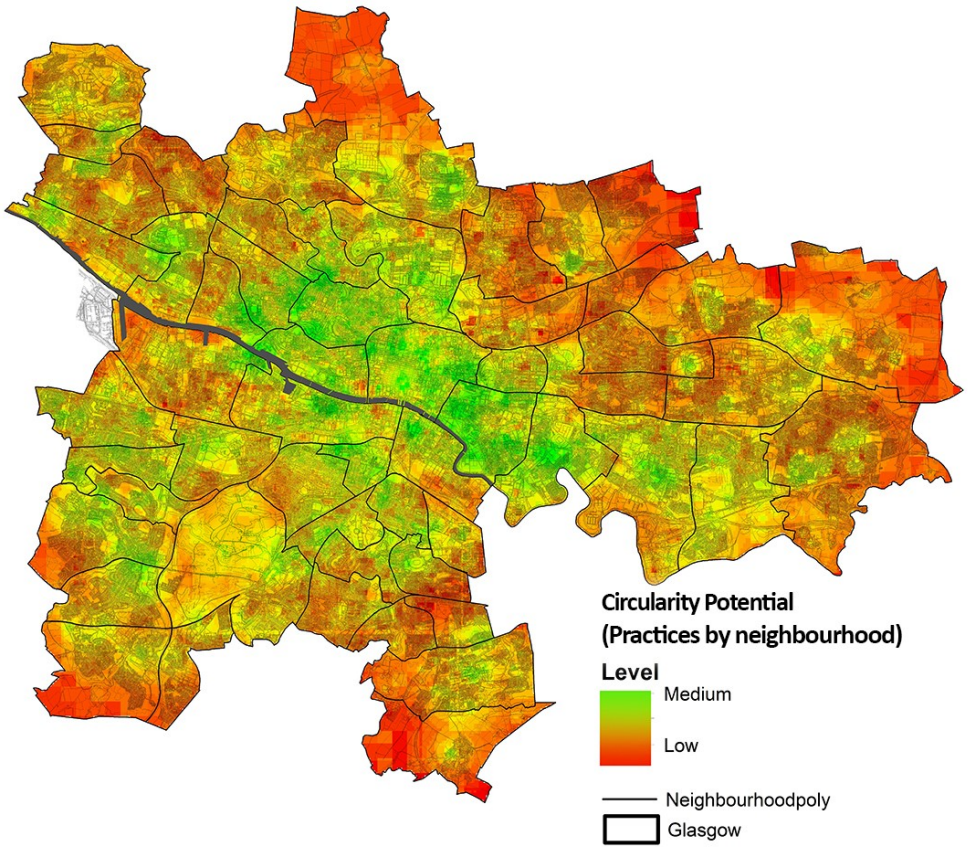


Figure 38. ***Distribution of circularity scores by pixels (cell size 1x1 m) within the neighbourhoods in Glasgow***

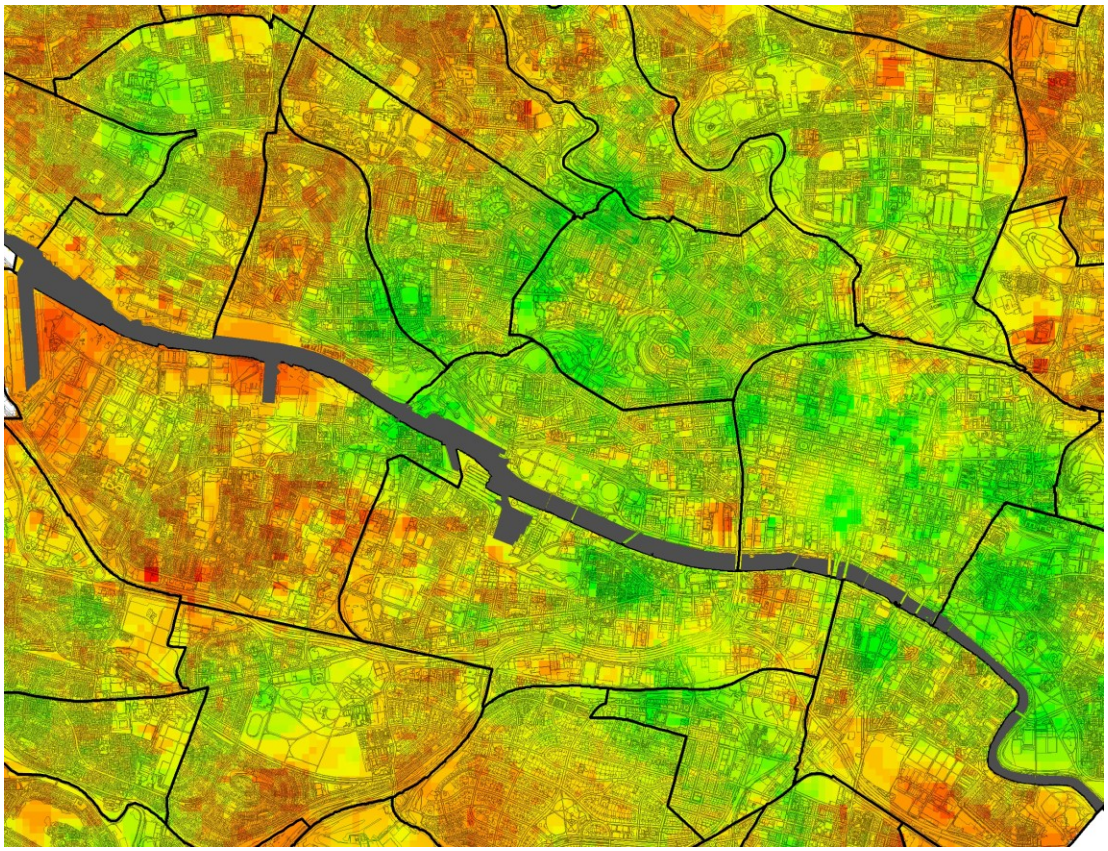


Figure 39. ***Distribution of circularity scores by pixels (cell size 1x1 m) within the neighbourhoods (ZOOM)***

5.5 CIRCULAR URBAN PRACTICE

5.5.1 Examples of implementation levers, strategies and metrics for monitoring urban circularity

Taking into account the literature review that was done at the beginning of this project (Phase 1: Understanding) and adding knowledge from the review of documents and interviews conducted for the case study (Phase 2: Localising), a set of practices and examples were identified and compiled in the Table 8, showing general inputs for the implementation and/or planning of circular urban practices. Moreover, as a graphic example for policymakers and designers, some strategies on functional flows are illustrated in a synthetic diagram in Figure 40. These flows could result from the application of plans and other levers of socio-spatial specific circularity.

Resource	Key Systems	General core issue	**Examples** of the appliation of Circularity **at the city level**		
			Levers that support urban circularity	**Pilots** towards the transition	Monitoring **Circularity** (Socio-Spatial dimension)
Material	All systems	Material consumption	If higher level of initiatives are missing: Circular procurement frameworks and plans with supplementary guidelines setting targets and regulations for Industrial and Commercial activities based within the boundaries of the local authority. If higher level of initiatives are in force: Implementing monitoring and reporting systems, or helping to the delivery through place-based plans for industrial symbiosis, optimisation and localisation. Requirement of metabolism assessments (LCA, MFA). Bio-regeneration schemes.	Circular Procurement Implementation in public assets, Annual awards of Industrial/Commercial Circular Procurement/Symbiosis practices. Circular metabolism grants. Circular construction and deconstruction incentives. Quarry regeneration projects.	Register of location and amount of providers and key supply chain players acording to the key sectors of the city (Key activities that support local competitiveness), Level of compliance to material and resource consumption targets, share of social responsibility of urban activities, share of imported versus recycled materials in the city, share of public contribution to green procurement, Number of eco industrial parks and companies involved in symbiosis.
		Material stock intensity			
		Use of the local natural endowment			
		Development of resource consumption over time			
		Use of renewable resources (percentage of imports net and domestic - consisting of biomass compared to total imports			
Waste	Socio-productive system	Waste generated by categories	Normally the targets and policies for waste management come from higher level institutions but at the city level therecould be some other levers: Local waste management plans, Local taxation and regulations on production of waste and management competences and other organisational efforts in terms of facility and logistics planning , Construction waste management frameworks, statutory guidelines and regulations, Landfill Managment, Official re-Manufacturing frameworks	Education and behavioural change campaigns and workshops for all stakeholders, Implementation of functional dematerialisation of public processess, Construction and operation of sustainable alternatives for local waste processing , PAYT (Pay as your Throw) Schemes. Combined Wastewater and heat pumps, Mandatory is-store electronic and electric waste collection. Biowaste and EfW facilities. Landfill regeneration. LOGA networks (Left over give away), Eco-design Prize, Green labelling schemes.	Waste generation and recycling figures per capita and per local activities, Percentage of the city's solid waste that is disposed of in a sanitary landfill, dump, incineration sites, versus more sustainable processing, Waste taken back by local industry, Level of awareness of the population on waste production and separation, Zonal coverage and level of participation of workshops on recycling, Community profiles in terms of consumption and production, Commercial profile of the retail and business sector in terms of waste production and avoidances. Identification of landfills, incinerators and other traditional waste processors, level of contribution of alternative sustainable waste processing systems, amount and zonal covergare of waste prevention programmes. Zonal coverage of waste collection facilities and in-store initiatives, Circularity of household consumption (Service against Product) etc. Location and share of packaging free or zero waste businesses, hotspots of litter reports in public spaces
		Methane producing organic waste diverted from landfill			
		Waste disposed (demolition, industrial, domestic, retail and service waste)			
		Household waste collection and processing			
		Landfill taxes and municipal levy			
		Hazardous Waste			
		Wastewater treatment			
		Electrical & Electronic Equipment Waste			
		Edible (avoidable) food waste			
Carbon and Energy	All systems	CO2 emissions (sopes 1, 2 3)	Similar to Waste management, most of the current policies and regulation comes from higher level initiatives. But locally these are leveraged by Local Carbon and Energy Plans, Local Carbon Management Plans, Sustaiable Transport Plans, embodied Carbon and Energy Analyses, Green Labelling for the industrial and construction sector, Retrofitting plans for existing buildings, Design guidelines for future developments. Carbon offset schemes.	Implementation of Zero-Carbon Zones, Reinforcing active travel, Embracing local reneable production in public assets and promoting it to other stakeholders, Place-based NBS projects, Carbon Taxing and Trade.	Domestic energy consumption by type, Amount of retroffited buildings towards energy efficiency, Share of renewable sources supporting public and private operations, Walkability index, Location potential of renewables per neighbourhood, Amount of cooperatives and active organisations working towards zero carbon initiatives, Rate consumption of goods and services produced in the city
		Consumption-based GHG emissions			
		Energy consumption buildings and activities			
		Energy recovery from residue stream			

Table 8 ***Implementing local circular urban practice (examples)***

Resource	Key Systems	General core issue	**Examples** of the appliation of Circularity **at the city level**		
			Levers that support urban circularity	**Pilots** towards the transition	Monitoring **Circularity** (Socio-Spatial dimension)
Blue and Green Resources	All Systems	Wastewater collection	The use of the green and blue assets is usually under the care of the environment departments of city councils. Nevertheless, sometimes focused plans are missing alongside programmes or schemes: Circular land management plans, water bodies and sustainable drainages management plans, Circular wastewater treatment plans, Urban forestry flans,	Ecosystem services projects, Biodiversity conservation inventories, Rainwater harvesting, brown and green roofs, plant-based production, Digital twins of trees and other green assets.	Percentage of buildings equipped to treat or reuse rain or grey water, share of wastewater succesfully treated, location and share of community gardens, growing spaces and urban forests, identification of urban biodiversity hotspots, Density of eco-serviced areas, share of bio-materials (wood) locally sourced, Location of timber harvesting zones.
		Wastewater treatment per type and sources			
		Rainfall and grey water logistics			
		Ecosystems preservation and management			
		Green belt preservation			
		Agriculture / food production			
Built assets	Property and built assets system	Building design and construction paradigms	Suplementary design guidelines for circular buildings, Circular construction and deconstruction frameworks, Flexible planning systems, Green certifications and third party verifications	Circular cities officer/department designation within the City Council, Building repurposing schemes, Interim-temporary use grants, Programme of land reserves for circular activities, Resilient adaptation schemes (e.g. reusing of buildigs to support public facilities under special cisumstances like COVID-19), Circular BIM Registers	Identificatin of urban mines (Material stock in buildings), Share of repurposed buildings, rate of at risk/rescued heritage, Location of temporary used plots, share of raw materials recycled from urban mines, Amount of certified buildings, Amont and coverage of material banks and similar facilities,
		Building management			
		Urban land management			
		Infrastructure and heritage			
		Suppy and demand of urban facilities			
Capital	Socio-productive system	Social and human capital	Innovacion Networks, Open Data Plans and Programmes, Environmental education plans, Socio-Economic plans, Economic Strategic Frameworks, Green certification and third party verifiers,	Green bonds, Climate bonds, Outreach communication chapters, Communnity incubation schemes, Social-entrepreneurship prokects, Business support campaigns,	Amount of businesses disclosing performance,Number of organisations with environmental management systems and certification, share of professionals in enabling fields for circulatiry, contribution of direct and indirect circular jobs, Amount of stakeholders receiving support for ciruclar initiatives, share of circular services and business in the city and per neighbourhood, city's global revenue from CE, registered patents and innovations, registered and acredtied university courses on CE, Citizen engagement in differente scales. Location of demostration projects and influence area,
		Information management			
		Innovation management			
		Financial management			

Table 9 ***Implementing local circular urban practice (examples)***

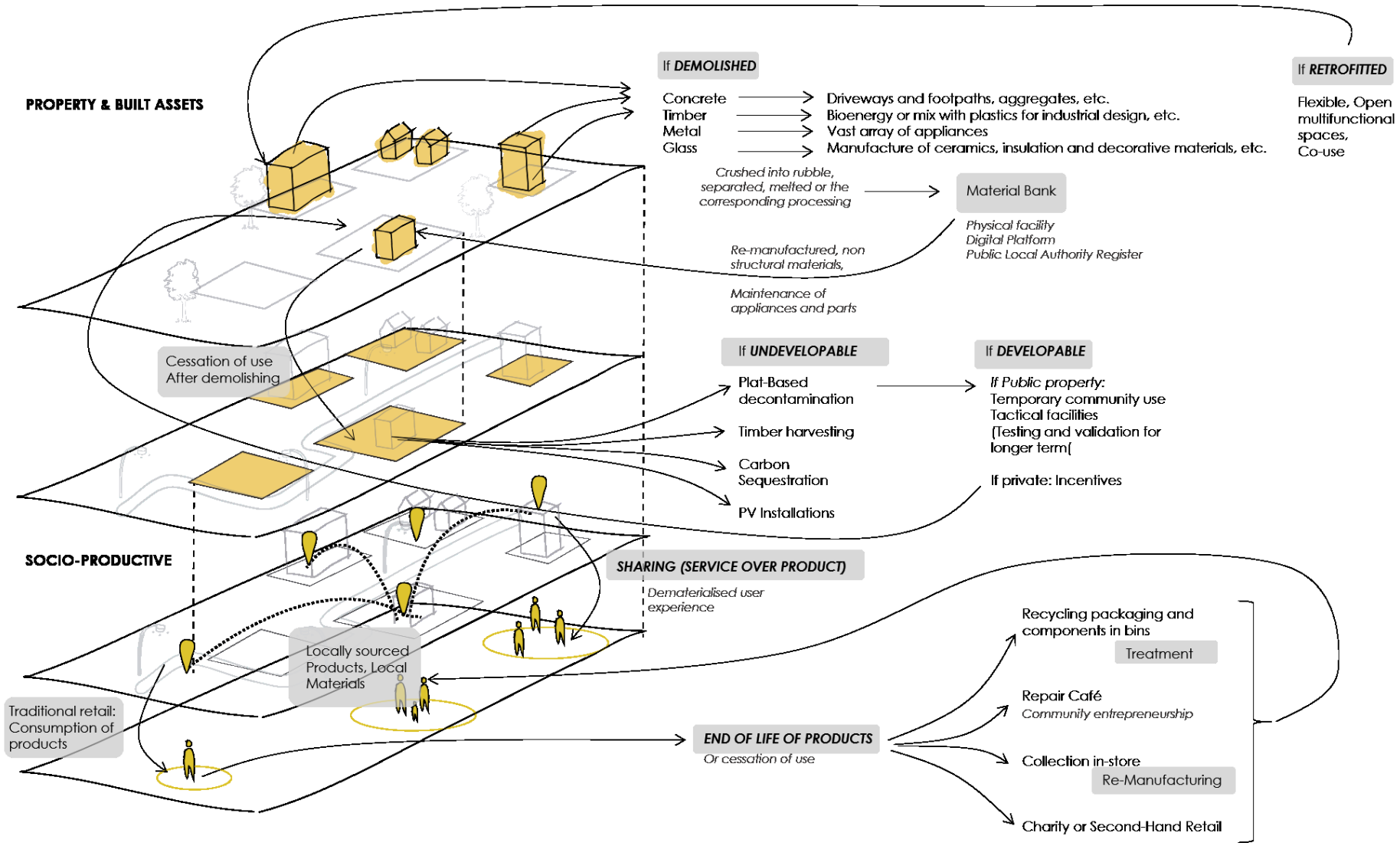


Figure 40. ***Circular flows in the socio-productive, property and built assets systems.***

CHAPTER 6

6 DISCUSSION, CONCLUSIONS AND FURTHER RESEARCH

After the results obtained surrounding the implications of the circular economy in the urban practice, and based on the information presented in the previous chapter, this chapter presents the discussion on the potentialities of applied circularity, its advantages and some barriers when embedding the circular economy planning and design processes within cities, bearing in mind its connections with other current trends. At the end of this chapter key concluding statements are summarised.

6.1 CIRCULAR AND SUSTAINABLE CITIES; ALIGNED BUT NOT INTERCHANGEABLE CONCEPTS.

In practice, the actions that local authorities are taking to tackle sustainability challenges are framed in different frameworks, most of the time coming down from the regional, national or supranational levels, and rarely designed directly at/for the urban level. Most European countries base their local agendas on guidelines from the European Commission and this includes the approach to the circular economy, which main promoters are supranational level organisations. However, there are independent exploratory practices that have gained exposure and ground for its application in local businesses and cities.

A common pattern among cities and organisations is that, typically, promoters of the circular initiatives come from fields connected to strategic and economic planning rather than spatial or urban-environmental planning, as happens with Circular Glasgow being an initiative led by the Chamber of Commerce, which unintendedly might have an impact on the scope and the type of pilots that are promoted, something that has been generalised in the academic work consulted for this research.

Moreover, as some cities have shown in practice (Amsterdam, Brussels, London, Glasgow) the local objectives that a circular city pursues are oriented to the dimensions pertinent to each context and reality (Williams 2019a, Vickery Hill et al. 2018, De vita et al. 2019), which naturally open a door to the nuances within the definition of circular cities according to the urban settings of its host: an emerging/developing city or legacy/pioneering city (CSCP 2019) and the spatial composition of its physical structure (Thomson & Newman 2018, Amenta & Van Timmeren 2018, EMF & ARUP 2019, Marin & De Meulder 2018). Therefore, the question is not only what is circular, but also; what does really work in certain urban settings?.

Glasgow is in a phase that could be considered as a post-shrinking one. A process that was initially led by the switch from industrial settings to services, combined with relocation, and other planning and policy approaches that indirectly shaped how the availability of urban resources - specially the spatial ones – is perceived, as well as the consequences of the lack of management of these resources; e.g. Glasgow having one of the largest stock of vacant land in the UK becoming a city that is sometimes associated to deprivation and unattended stocks in contrast with London having limited spaces to develop, which leads to land value speculation and a market competition that, in some cases, pressures the development of techniques and policies to maximise the use and availability of spaces.

Even though this dissertation did not intend to come up with a definition of circular cities, at the beginning of the research work it was important to review what the state of the conceptualisation was, in order to offer some contribution to the discussions on this matter; even more considering its differences and overlaps of the circular city definition with that of a sustainable city and other concepts such as the liveability of cities (O'Donnell et al. 2019). Also, these contributions help clearing the understanding regarding the drivers and targets of the sustainable and circular agendas (Bristow & Mohareb 2019).

After the review and the knowledge gained in the whole process of elaboration of this research work, it was identified that sustainable and liveable cities are seen within a broader framework of the sustainable urban development; i.e. aimed to tackle the 'triple bottom line' challenges in urban areas, whereas a circular city is a more specialised way of understating cities as metabolic resource mines. It is in this specificity that circularity could contribute to some sustainability aspects, but sustainability does not necessarily lead to circularity. In the same line, it must be also considered that while a sustainable city might tackle climate change issues, a

circular city, or the idea of circularity itself, is directly framed in managing the dialectics material and resource crisis / climate crisis.

For some practitioners, there is a need to question the terminology of 'sustainable city', because we are not "sustaining" a status quo anymore, as when the term sustainability emerged. Opposite to this, the aim is to regenerate cities in terms of innovation, resources and urban communities (Schurig, 2018). If well managed, circular cities can be the hubs of innovation and creativity to provide the adaptive solutions required amid the resource scarcity threats, fostering mitigation and adaptation measures in terms of energy, building, mobility and planning efficiency to deliver major emission cuts while improving resource flows; pursuing the Sustainable Development Goals (SDG) without compromising economic development (UN-News 2019), as perceived not only from the literature but from the comments and views obtained in the interviews (Section 5.2.2).

The concept or circular economy itself, as described and defined in the literature, represents a strong theoretical potential to achieve multiple SDGs; directly facilitating goals number 11, 12 and 13 on achieving sustainable cities and communities, sustainable consumption and production and climate action, respectively. While also supporting goals 7, 8 and 9 on clean energy, economic growth and industry innovation. Furthermore, Circularity could be leveraged towards meeting goals 14 and 15 and 3 as to safeguarding/bio-regenerating water and land assets, as well as fostering good health and well-being of people through behavioural changes. This is not a statement that circularity is the latest masterclass response to solve all urban challenges. But the practical and prescriptive (instead of descriptive) conception of circularity - as a systemic approach- could have an important contribution in maximising resources within the urban systems, by not only to quantifying but spatialising and implementing localised actions to enhance the stock and flows of what we have in cities at different scales (section 5.1).

In a city, the definition of a scale matters, as scales are interconnected with the role/competences of urban players. A circular economy and a circular city have different scopes. Thus a circular city cannot be seen as a compilation of circular economy initiatives only, it must also fully realise and exploit its potential to be a cradle for circular development, and use its governance tools and levers as catalysts for circular change (EIB 2018a, p 4).

Circular city agendas are sometimes merged with other initiatives within innovation and sustainability; for instance, in Amsterdam the idea of circular cities is closely related to smart cities, in Paris it is to behavioural changes, involving localisation and household profiling as means for efficiency, in Glasgow business sectors are key and community engagement/awareness are the base of the CE movement, incorporating innovation in businesses by looping resources between different streams. Overall, some indirect and direct aspirations of circular cities, as mentioned in the literature and reports used for this work, should be the reduction of carbon emissions, relieving pressures on municipal services and budgets, encouraging innovation-rich urban economies, increasing liveability (by improving waste and water treatments, air pollution, less time travelling, less congestion) and increasing positive impacts on local employment (Section 5.2.1). But we cannot forget that before CE there were, and still are, plenty of unlabelled initiatives that go on the same direction. How are we recognising them? How can we connect them instead of getting distracted by new terms?

6.2 LOCAL AUTHORITIES AND INSTITUTIONS FOR A CIRCULAR CITY

To speed up the transition towards a circular city, it is crucial to understand the relationship between socio-economic, functional and environmental dynamics of the built environment. This is a broad scope that can be addressed with the synergetic help of government, institutions, policymakers, industry, universities and civic organisations.

As international institutions have a role in setting standards, coordinating, and encouraging the circular transition, the public sector needs to provide infrastructure, policies and regulations 'that incentivise innovation without imposing burdens that dampen growth' (WEF 2018, p. 23). The business sector plays a role in innovating and inspiring, while investors support, fund and help to scale up the opportunities for those businesses. Similarly, academia impulse research and education on relevant topics of circularity (Ibid). All these aspects and synergies must be considered in planning and development frameworks, for instance; in most academic literature, urban planners, policy makers and other actors involved in decision making are acknowledged as enablers of co-creation processes beyond individual projects. Thus, understanding the spatial impact of the current linear economy on the quality of land and the

health of the urban economies demands changes in governance approaches (Remoy et al. 2019) which cannot be achieved without a local authority's support.

From the inputs obtained in interviews, there is a high recognition of the challenges of turning circular ideas into policies, to secure sustainable funding and producing the required regulations to mainstream the pilots and demonstrations. Although the circular movement has been growing in Glasgow with increasing inter-city partnerships; as the recent alliance with Circular London, policy-makers recognise there might still be insufficient funding and support the circular city way. In that sense, the development of CE strategies are often made in silos, and the current legislations sometimes hinder innovation.

Glasgow City Council has been an enabler and supporter of some core circular actions in different scales; for instance, by giving space for social innovation such as in the *Stalled Spaces* project that has been running since 2011 and provides small grants to implement pop-up and temporary use of vacant land, a valuable tool for testing and validating incremental changes. On the other hand, other programmes or plans, that somehow contribute to core circular actions; especially collaboration and optimisation strategies, come from intertwined planning and strategic partnerships between the local authority and other organisations with different scopes and timeframes for its implementation. Nevertheless, the piloting approach shows that micro-scale projects can be leveraged and mainstreamed. Hence, some benefits could emerge in practice if proper alignment or connections are made between the agendas and stakeholders when trying to implement these initiatives. The *Transition Towns* movement, could be one example of the way to start, but further research could help to assess in more detail the actual benefits of scaling up processes of circularity via piloting.

At the time this dissertation was written some data about the progress of CE initiatives in Glasgow and key performance indicators are being analysed and yet to be published by the institutional consortium in charge of Circular Glasgow (as declared by some respondents). Similarly, the CE route map for Glasgow is yet to be approved by the administrative authorities. However, from what is so far published and could be analysed using the sources available for this work, the approach to sustainability and circularity taken by Glasgow, although having well-defined connections to engagement and the improvement of wellbeing in the city, does not focuses on spatial regeneration, which remains not only as a hot topic but also as a key

opportunity for Glasgow amid a circular transition to support what some authors define as spatial justice (Amenta et al. 2019c).

6.3 THE SPATIALISATION OF THE CIRCULAR ECONOMY

Spatial planning and design are normally facilitated by urban-geographical approaches as to the urban systems are not only functional but physical. As an exercise, following the objectives of this dissertation, the phase of localisation was focused on spatialising variables and practices relevant for urban circularity and this mapping process allowed the profiling of Glasgow from a city-wide perspective to illustrate the 'where' and the 'how' of circular initiatives in this city.

As stated in the methodology, 10 sets of maps were produced using different data sources that gave a general picture of the quantity and the spatial distributions of material, wastescapes, activities and patterns here discussed.

6.3.1 Spaces and Buildings

The first set of maps, related to the property and built assets system, is important to understand that aspects like the stock of material and wastescapes are relevant for the forecasting of physical urban futures in terms of dereliction/demolition and material loss. Glasgow is a city that has been facing challenges in terms of regeneration after urban dynamics influenced its particular path from an industrial to a service city, which can be evidenced in the high amount of spaces demanding retrofitting and repurposing actions across its urban landscape.

Understanding the material stock of Glasgow (Section 5.3.1.1) serves to visualise the future potential of urban mining, as well as the opportunities that can emerge regarding the maintenance of these assets. Normally, most of the material content in buildings corresponds to structural materials that is hard to re-allocate, whereas the non-structural material; pieces and applications that are replaced during the life cycle of the building, could be the focus to start implementing circular urban practices (Stephan & Athanassiadis 2018).

Similarly, by categorising and identifying clusters of wastescapes (Section 5.3.1.2), a better approach could lead the re-evaluation and monitoring of effective land use;

for instance, in Glasgow the category of wastescape WS3: corresponds to dross scape mainly from the road infrastructures, but this same portions of land are usually considered as 'green corridors' within the open and green spaces categories, even though most of these spaces are not being nurtured to offer proper enhancement of the public space network or allocated ecosystem services.

The way in which the wastescapes are seen in most papers and research that have Glasgow as a case study, are focused on the negative effects (Maantay 2013, Maantay et al. 2015 Mcdonald et al. 2018) rather than the potential recovery or re-programming of those. This is something that the circular perspective can bring to guide the current local endeavours in the right direction, as that of some studies which consider vacant land as labs for timber harvesting, the use of the urban biomass and PV farms pilots (Clarke et al 2015; PBA-Stantec 2019).

The recovery and repurposing of land and buildings in cities involves more opportunities than simply bringing back to use these assets (Section 5.3.1.3) as proposed by the circular land management frameworks (CirUSE). This circular practices encourage planners and designers to rethink not only the management of these assets but also the flexibility and potential of the functions they can host. This is a matter of resilience, which is required in certain circumstances to support the delivery and coverage of specific urban services and facilities currently in shortage; e.g. the temporary re-purposing of buildings that was deployed not only in Glasgow but in other cities of the UK to provide ambulatory services amid the pandemic COVID-19, i.e. music venues into temporary attention centres, or the post-pandemic approaches that envision a new role for the street networks as an extension of the plots for uses that support local economies (open street restaurants, cafes, etc.) are examples that should make planners more aware of the application of more flexible/sustainable planning and design, incorporating the circular perspective.

Today, more than ever, we are aware that changes in the patterns of use of public spaces and the local economies depend on external issues too. What was experienced during the lockdown amid COVID-19, is a reminder of why flexible and versatile spaces are required if we want to build future-proof cities.

6.3.2 *Businesses, services and community interactions*

The spatialisation of commercial and retail activities, apart from bringing the functional-economic perspective of circularity to the spatial planning ground, help to identify the profile of the city in terms of the presence of certain business models that could supplement others towards a better cycle of the resources within them, e.g. Glasgow is piloting the use of waste bread to be turned into beer as one of the circular local business ideas to be piloted in the city, and apart from that there are other opportunities that should be considered under the type of circular business that best fit the predominant economies in the city. Similarly, other services and facilities (public or private) to support businesses and engage other stakeholders could be promoted, such as material banks for communities interact with the construction sector, the offer/demand of in-store collection points for certain streams of waste, implementing alterative packaging programmes in take-away shops, or other ways to 'circularise' traditional businesses. All f these taking into account that even though a full disruption is not a straight-forward process, there are different conditions that can help to pave the road.

Additionally, the provision of certain facilities can help promoting more sustainable and circular approaches; in Glasgow there are some schemes of bike rental stations and charging points for electric cars, but as maps showed, those are so far concentrated in the central zone. This needs to be extended to other parts of the city along with incentives in zones where car ownership is very high. On the other hand there are many implications and variables that affect mobility choices and also energy use, which are not the central scope of this dissertation project but must be considered as one of the most relevant aspects of consumption-led emissions within the metabolic dynamics of circular cities.

6.3.3 *Scales within the city: thriving circular neighbourhoods and place-based approaches.*

Bringing the circular economy principles to cities has an inherent connection with spatial planning and design, as these fields guide the understanding of urban processes and inform prospective future actions in urban areas. Thus, urban circularity can be seen as a multi-scale dynamic concept which actionable scope varies according to the scale to which the analyses and proposals are intended. The microscale: circular building design can help to integrate governmental and behavioural aspects to the perspective of sustainable building design (Pomponi &

Moncaster 2016) and furthermore could also be scaled up from the architectural to the landscape and urban design scope by looking at the stock of initiatives and their performance at the neighbourhood level.

The mapping exercise in section 5.4 cannot be taken as an integral methodology to measure circularity but instead to envision the allocation or improvement of circular initiatives. The neighbourhood scale has the potential to bridge the gaps between planning and design while making the most of local participation and cooperation thereby facilitating a sense of belonging in the process. At the same time, the neighbourhood scale is a good ground for demonstrations of disruptive approaches and validating innovative planning tools and facilities for a circular transition; banks of materials, community repair cafes, rethinking the role of blue and green surfaces (the landscape as a provider of ecosystem services), physical and digital platforms and other provisions that facilitate the delivery of the circular agenda in cities.

Finally, the nature-based solutions and the ecosystem services are among the aspects embedded in urban circularity, as they incorporate the premises of sustainable and green approaches to the resource-led system thinking, the city as a living organism. As reviewed in the latest projects, plans and programmes, Glasgow has been integrating these perspectives in some initiatives, but there is a long way to take demonstrations to its borad practicability and financial feasibility.

6.4 CONCLUSIONS

The circular economy is a developing concept that has received contributions from both academia and practitioners in the last 10 years. It is a dynamic concept that has incorporated dimensions and scales from an industrial ecology background to become into a multi-sector and system level approach. Circular cities are a recent application of this concept and it has gained more advancement from the industry and practice rather than academic contributions; i.e. unlabelled initiatives from international organisations guiding the knowledge transfer and demonstrations, an increasing amount of cities self-defining as circular, etc. Urban circularity is a contextualised concept that varies according to the social realities, local economies and the characteristics of the urban settings which the agendas are designed for. Moreover, circular projects need consolidation by actionable strategies, otherwise they will end as marketing flagship labels, instead of actual disruptive solutions.

The idea of urban circularity is not dissociated from urban sustainability, it contributes to the latter but in a more specialised and tailored way, focusing on resource management in cities from a metabolic perspective. While a sustainable city remains as an umbrella concept from which a plethora of other related concepts emerge, a circular city is a more practical and grounded model that incorporates aspects of sustainability, offering an alternative to escalate climate-sensitive planning by incorporating consumption and production perspectives into local planning while responding to global issues; i.e. the climate crisis, associated to a resources crisis.

There is a fair diversity of frameworks and principles for the circular economy, with an emphasis on business models and strategies aimed to rethink the procurement and the production of goods and services. Yet, there are silos for its application in urban areas, a gap this research work is built on, facilitating the construction of a socio-spatial perspective of the strategic elements of circularity and its visualisation amongst the urban layers/systems to inform urban planning and design.

This work shows how the lens of urban circularity bring the resource-driven approach to the design of urban mechanism (through an exercise of visualisation) that can help policymakers to enhance urban cycles, with an emphasis on 'where' these resources and circular practices are distributed, especially the built assets and the socio-productive networks. Similarly, by getting the stakeholders' view, along with the review of the case study, it was confirmed that engagement and collaboration go hand in hand with the required synergy of parties involved in this kind of system-thinking models, where individual choices are systematically intertwined with broader scarcity and/or efficiency. The premises of a circular city are based on ecological and metabolic cycles: the outputs of one part are the input of another, and this can be transferable not only to the design of facilities, buildings, industrial parks and neighbourhoods, but also to planning processes of both intra and inter-city connections. Multi-scale cooperation are levers that facilitate circular flows, but there is a recognition of a series of challenges and barriers for achieving a comprehensive circular system, which depend on changes of the current cultural and normative structures to incentivise and mainstream the circular demonstrations.

Because of its post-shrinking characteristics, the built environment of Glasgow has the potential to be better re-cycled in a circular way, also taking into account aspects related to reutilisation of vacant land and landscape for ecosystem services, timber, solar or rainwater harvesting, and the built assets for urban mining of material by the substitution of non-structural in the middle and structural ones in the long term.

In terms of the socio-productive system, current circular practices in Glasgow should be leveraged as catalysts to make other sectors that are harder to turn into circular more engaged. Similarly, local communities and networks that emerge, e.g. within urban gardening and permaculture groups (considering that farm shops were one of the top categories of circular business in Glasgow), could receive more support to scale up the localisation of certain productive activities as demonstrators towards a circular society based on local production and facilitates a sense of belonging, and incremental impact on the kind of entrepreneurship that could emerge in the future.

Glasgow started its circular journey in 2016 with the circle scan and has tried raising awareness and engagement within the business and public sector. The city is about to publish a route map that might guide the next steps towards the spatialisation of circularity; potentially embedding urban circularity in the construction and development sectors. All these has been supported by the momentum gained since 2010 after the creation of the Sustainable Glasgow Partnership. This case illustrated the relevance of the institutionalisation of initiatives and the value of having support from upper levels of government to secure continuity and further development of the circular agenda in the city.

As a final conclusion, it worth mentioning that the resource-based perspective promoted through the circular movement is highly relevant to our era, not only because of climate issues but also because global threats require cities to build more resilience. Circularity is not only the capacity of adapting but reacting to new conditions, something that during these testing times amid the global pandemic have influenced the way we perceive economic and spatial planning in our cities, especially in terms of the re-design of facilities and services and their spatial requirements.

6.4.1 Limitations

This research was done mainly collecting secondary data (both qualitative and quantitative) from literature review, official and open sources, supported by interviews to gather primary information from key stakeholders. The outcome of the study is limited to a review that summarises and identifies the presence and relevance of resources in the urban systems in order to visualise strategies to encourage circularity within the spatial planning domain. This was informed by a case study, so the outcome of this thesis represent a context-specific picture not an assessment tool that can be directly applied to measure circularity as a whole.

This work is a contribution to ongoing explorations on the spatialisation of the circular economy and its practicability to inform urban planning and design. The appraisal of the case study is contextualised and comparative. It suggests further knowledge explorations to cover current gaps on the socio-spatial dimension of circularity and its local implementation.

Finally, although started earlier, most of this dissertation was developed during the pandemic outbreak (COVID-19), which affected the initial plan and methodology thought. This challenged data gathering and other procedures; interviews made were 100% online, as well as the desk-based data collection, which in normal circumstances could have been supplemented in more traditional ways.

6.4.2 Opportunities for future research

This thesis contributes to fill some gaps mentioned in the Chapter 2, section 2.5. but there is still a wide range of opportunities for future research in terms of the spatial representation of circularity (Ibañez 2019) and the notions of urban metabolism associated to circular urban interventions (Perrotti 2020) with explicit social involvement (Marin and De Meulder, 2018) and the socio-cultural structures underlying the potential of CE (korhonen et al. 2018). On the other hand, more knowledge building upon this thesis work could be directed to further analyses of urban systems as circular systems with a deeper emphasis on the flow instead of the stock of resources and practices.

Similarly, the connections between the climate crisis and the resource crisis could be better explored based on the spatial perspective this thesis built. For instance, analysing pollution directly associated to specific urban waste-streams, or the research could be directed to urban climate aspects, exploring for instance how the predominance of certain materials in some areas could be correlated to micro-climate issues, or exploring how the spatial distribution of spatial assets such as bare soil, vacant land and derelict spaces impact on the local climate, by following the premises of Local Climate Zones. Moreover, the identification of a taxonomy of circular urban activities and land uses, including the use of incremental-tactical planning techniques, as well as formal metrics for measuring circularity at different levels, need to be nurtured towards the evolution of climate-sensitive planning and design techniques.

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Note:

The complete list of policy documents (plans, programmes, projects) consulted for the case study is provided in the Appendices, with a description and the link to access them.

8 APPENDICES

City documents reviewed in the case study: Glasgow.

NAME OF THE DOCUMENT/PLAN/INITIATIVE (LEVERS)	AUTHOR	OVERVIEW	LINKS
Sustainable Glasgow Board, Since 2010 -ongoing	GCC	As a board it was set in 2010 but this partnership has had a key role in promoting and tracking many initiatives throughout its foundation.	
Air Quality Action Plan 2009 - 2019	GCC	This document sets out Glasgow City Council's 2009 Air Quality Action Plan and aims to improve air quality in the AQMA (Air Quality Management Areas). The Plan sets out a number of actions, ranging from Low Emission Zones to Tree Planting, that have been identified to reduce levels of the air pollutants, in yearly reporting, the refreshment of some actions such as the different scheme introducing car sharing, cycling infrastructure improvement and electric/ hybrid vehicle are introduced	https://www.glasgow.gov.uk/localairqualitymanagement
Stalled Spaces since 2011 - ongoing / Spaces for Growth	GCC, GHA	Promotion of temporary use of underused or vacant spaces for a variety of community services or activities such as growing spaces, pop-up gardens, events or exhibitions or any other innovative idea	https://www.glasgow.gov.uk/article/17878/Stalled-Spaces-Glasgow
Open Data Glasgow	GCC, EU and Scottish Government	Platform supported by the GCC, offers an overview of available datasets, but seems to be poorly updated. It is not clear if the project is still running or has been stuck for a while.	http://data.glasgow.gov.uk/
Understanding Glasgow 2011 - Glasgow Indicators Project	Glasgow Center of Population and Health	The project manages to compile a rich amount of data and also communicates it in both a descriptive and visual manner, the project helps the comparison by neighbourhoods which, although subjective in terms of boundaries, is very useful and valuable for that scale of planning. Thereby supporting digitalisations and the envisioning of place-based strategies	https://www.understandingglasgow.com/about_the_project/about_the_project

Energy and Carbon Masterplan (ECM) 2013	STEP-UP, GCC, StrathClyde University	The Energy and Carbon Masterplan (ECM) sets out a vision of a transformed energy economy for Glasgow that is based on low carbon and increasingly de-centralised energy sources that are better able to meet Glasgow's energy needs and help Glasgow tackle climate change. The ECM builds and extends the current collaborative working arrangements on energy and sustainability in the city through the work of the Sustainable Glasgow initiative and is a key strategy in helping deliver Glasgow's aspirations to become one of Europe's most sustainable cities the plan itself is guided by great strategies towards switching energy provision while lowering carbon emission and polluting sources for heating. It also draws the intention of collaboration and promotion of local scale initiatives or ´small scale community schemes' but as a promotor rather than a supporter and enabler, it introduces the energy from waste alternative and aims to the efficiency and improvement of the management of systems across all sectors, specially the residential. Finally it sets actions for continued engagement of actors for the delivery of new energy systems but the 'how' of the execution is unclear from the document.	https://www.glasgow.gov.uk/carbon
Carbon Management Plan, Phase two 2013-2021	GCC,	This version of the Carbon Management Plan (CMP 2) covers the period 2013 to 2021. It follows the work undertaken between 2008 and 2013, which set a 20% carbon reduction target by 2013 against a 2005/06 baseline. A review undertaken in July 2013 showed a reduction of 9% had been achieved. A 30% reduction target has now been set, to be achieved by 2020/21 against a 2005/06 baseline. This is in line with the Scottish Government's interim target of 42% reduction (against a 1990 baseline) and complements Sustainable Glasgow's target for the city of 30% reduction by 2020/21.	https://www.glasgow.gov.uk/carbon
i Tree Glasgow 2013	Forest Research	Survey aimed to get data for analysing and promotion ecosystem services in the city by knowing the state of the nature (specifically trees) in the urban area of Glasgow, they found and classified the samples as well as the land and context around them and possibilities of urban forestry and harvesting	https://www.forestresearch.gov.uk/research/i-tree-eco/i-tree-eco-projects-completed/i-tree-eco-glasgow/
Future City Glasgow and Open Glasgow 2013-2018	Future City Glasgow	This is an interesting mixed approach of digitalisation, because it used both in situ and digital techniques to map the city from different stakeholders, the amount of people participating was significant. Although the outcome and uses of data collected is not clear in the document reviewed, as well as next steps.	https://open.glasgow.gov.uk/future-maps https://futurecity.glasgow.gov.uk/
Resilient Glasgow City Strategy and Framerwork 2014 - ongoing	GCC, ARUP, Rockefeller Foundation	This Resilience Strategy is the main output of our work with 100RC to date, and the starting point for a holistic programme of resilience action. Whilst adaptation to climate change remains a principal focus of Glasgow's approach, the Resilience Strategy is broad with a strong sense of collaboration and community building, the localisation and formulation of policies to cover	https://www.glasgow.gov.uk/resilience

		gaps in environmental, social and economic issues, as well as the adaptation of the city, management of the built assets and recovery of resources.	
Waste Strategy Action Plan 2015-2020	GCC	The strategy described shows connections with other strategies and departments such as the carbon management team. The action plans from 2015 aims to improve the recycling rate and the reduction of waste generated too so the action towards optimisation seem to show important efforts, at least on paper	https://www.glasgow.gov.uk/article/16572/Waste-Strategy
Glasgow City Centre Strategy Action Plan 2014-2019	GCC and partners	According to the website, the strategy is ongoing, executing and developing next steps. It is a well-spatialised strategy that covers key aspect of urban environmental issues to make a better city centre.	https://www.glasgowcitycentrestrategy.com/
Economic Strategy 2016-2023 and Leadership Board	GCC,	This strategy offers a vision for the development of different key sector, from services and businesses to technology and low carbon. The aim is to thrive the local economy of Glasgow while allowing innovation, the scope of the strategy if very broad and it combines actions and partnership with other actors. Also the Circular Economy is mentioned as one aspect to be developed	https://www.glasgow.gov.uk/article/20421/Economic-Strategy
City Development Plan 2017 - ongoing	GCC	The plan for the city set a broad action plan covering most of the areas needed. Also, this document is connected to a series of other strategies and supplementary guides	https://www.glasgow.gov.uk/cdp
Strategic Development Plan 2017 - ongoing	Clyde Region	The plan for the city set a broad action plan covering most of the areas needed. Also, this document is connected to a series of other strategies and supplementary guides	https://www.clydeplan-sdpa.gov.uk/strategic-development-plan/current-plan/current-strategic-development-plan-july-2017
Connectiong Nature 2017-2022	GCC, EU and internation al network	Develop planning processes that enrich and nurture social, business and governance innovations and focus on the scaling-up of nature-based solutions, interdisciplinary work and stakeholder engagement in cities.	https://connectingnature.eu/
Community Action Plan 2018-2020	GCP. GCC	This document sets the different actions that involve different parts to work collectively for the improvement of the community opportunities through the reinforcement of skills and employability, also tackling aspects related to urban services such as transport and other facilities that were considered as priorities by the surveys.	https://www.glasgowcpp.org.uk/index.aspx?articleid=21363
Local Biodiversity Action Plan 2017-2027	GCC	This document describes the aims, objectives and actions for the LBAP in the period 2017 to 2027. The core objectives remain the same, to protect and enhance biodiversity in Glasgow and to raise awareness of biodiversity to local communities through education, engagement and promoting access to parks, Local Nature Reserves and other urban green spaces.	https://www.glasgow.gov.uk/biodiversity

Strategic Plan for Cycling 2016-2025	GCC, Sustrans	This strategy sets the targets of doubling the amount of cycling in the city and aims to collaborate with different organisations not only locally but regionally to deliver an improvement for the city along with neighbouring authorities. The Strategy does not mention sharing systems or technology involvement.	https://www.glasgow.gov.uk/CHttpHandler.ashx?id=33403&p=0
Housing Strategy 2017-2022	GCC	This strategy has a strong emphasis on the provision of efficient housing according to national standards and the affordability as well as the amenities (green spaces) and facilities to enhance the liveability of communities	https://www.glasgow.gov.uk/CHttpHandler.ashx?id=4584&p=0
Circular Glasgow 2016 - ongoing	Chamber of Commerce	The document describes the principal streams of consumption from the key sectors selected for the city scan and present some pilots related to demonstrations in the business sector of Glasgow	
Recycling and Renewable Energy Centre (GRREC) 2019 -	GCC, Viridor	The facility handles 200,000 tonnes of council green bin residual waste every year. Works in combination with city wide blue, brown and purple bin recycling to diverts 90% of green bin residual waste away from landfill, releasing recyclable resources from household waste	https://www.viridor.co.uk/energy/energy-recovery-facilities/glasgow-rrec/
Climate Emergency Working Group 2019 - ongoing	Sustainable Glasgow,, GCC	This group serves as an external advisor and in conformed by a series or member organisations that promote climate action. The recommendations made in the report reviewed are updated and relevant to the circular economy agenda and climate change targets.	https://www.thinkdifferentevents.co.uk/events/sustainable-glasgow-partnership/working-group-report.html
Zero Carbon Communities (ZCC) Glasgow 2019- ongoing	Scottish Power	The ZCC encourages the transition to an optimised and better energy system by partnering with mobility technologies and providers to deliver share bike systems and charging points for electric cars. The Budget has been set and the time horizon so far is 2022	https://www.scottishpower.com/news/pages/glasgows_path_to_net_zero_revealed_in_detail.aspx
ParkPower (National Project with city-level Data) 2020	Green Spaces Scotland	This project is a nationwide initiative that has delivered a methodology and digital platform that aims to promote the assessment of potential to incorporate renewable technologies in the park at the city scale.	https://www.greenspacescotland.org.uk/pages/category/energy
Glasgow City of Science	Partnership	The programme aims to capacity building on	https://glasgowcityofscie

and Innovation 2020-2023		technology, advanced manufacture, low carbon means and other sector that were identified as catalysts for the economy and the well-being of Glasgow.	nceandinnovation.com/
Property and Land Strategy 2019-2029	GCC	Both the property and land strategy and plan follow address vacant and derelict land assets as one of the key action areas for the delivery, taking into account the necessity of reusing and repurposing spaces, the delivery of it is supported through ongoing programmes but also it intends to be improved and more spatialised.	http://www.glasgow.gov.uk/Councillorsandcommittees/viewSelectedDocument.asp?c=P62AFQDN0GT10G81DN
Vacant and Derelict Assets Plan 2019-2029	GCC	The strategy recognises the role of vacant land for the city and the different alternatives that can be considered not only to help communities but to thrive local economies.	http://www.glasgow.gov.uk/councillorsandcommittees/viewSelectedDocument.asp?c=P62AFQDN0G0GNTDNZ3
City Centre Living Strategy Vision 2020-2035		This is an updated version of the city centre strategy that incorporates some environmental aspects related to the targets of the city to optimise and incorporate the vision of the different boards and collaborators involved. E.g. the circular economy concept is recognised in the agenda as a key aspect to be developed in the future.	https://www.glasgow.gov.uk/article/25299/Glasgows-City-Centre-Living-Strategy-aims-to-double-areas-population
Digital Glasgow 2020 - ongoing	Digital Glasgow	This strategy sets out our priorities and commitments to developing Glasgow's digital economy and transforming our public services, including planning, through the use of digital technology. It has been developed in collaboration with a broad range of partners from across the public, private, third, and academic sectors and embraces circular economy and smart cities principles	https://www.glasgow.gov.uk/article/17711/Digital-Glasgow
Open Space Strategy 2020	GCC	The Open Space Strategy sets out a vision for Glasgow's open space that has been shaped by the prevailing policy context as well as other factors, such as the reduction in Council budgets. It sets out a number of existing and proposed actions for the Council and its partners to deliver A Liveable Glasgow, A Healthy Glasgow and A Resilient Glasgow	https://www.glasgow.gov.uk/openspacestrategy

Review and synthesis of circularity principles.

Author	Year	Document	Type									
ENEL	2019	Circular Cities, Citis of Tomorrow (Second Edition)	Pillars	**Circular Inputs:** The use of inputs from renewable sources (both material and energy) or from reuse and recycling	**Extension of the useful life:** Every specifc action aimed at extending the useful life of an asset or product vis modular design, predictive maintenance, etc	**Product as a service:** Business model whereby the customer, rather than purchasing the product, purchases the related service.	**Sharing platforms:** Enabling individual to share their assets	**New life cycles:** Solution aimed at preserving the end-of-life value of an asset. Reusing, Regenerating, Recycling.				
STOPWASTE & ARUP	2018	Circular Economy in the Built Environment: Opportunities for Local Government Leadership)	Guiding Principles	**Utilization:** Tackle underutilisation of building and spaces, Increasing the utilization rate out of each square foot of built environment.	**Flexibility:** Tackle building demolition by designing buildings to be adaptable as needs change over time and flexible for multiple concurrent uses and increase flexibility through building codes.	**Asset Value:** Buildings should be designed to maximize asset value today while also enabling the extraction of material value from them in the future.	**Lifecycle Impacts:** Consider all the stages of making, using, refurbishing and disposing/recycling an object and the associated environmental impacts.	**True Cost Accounting:** Estimate socio-emvironmental costs/benefits from activities that lead to effects like pollution, blight, congestion, and climate change.				
Ellen MacArthur Foundation *	2015	Growth Within: A Circular Economy Vision for a Competitive Europe	Pillar Actions	**Regenerate:** use of renewables, return recovered resources to biosphere, reclaim, retain restore ecosystems	**Share:** maximise use (reuse/secondhand) and share	**Optimise:** increase performance/efficiency, remove waste, leverage data	**Loop:** keep componentes and **materials** in closed loops, digest, extract	**Virtualise:** dematerialise directly and indirectly	**Exchange:** replace products/services/ technolgies for lower resource-consuming optiones	**Adapt:** plan and design cities to allow for adaptation	(Added by Williams 2019a) **Localise:**Localisation of resource flows and activities (consumption and production) within the cityregion to develop local symbiotic capital and encourage pro-	
European Union	2020	A new Circular Economy Action Plan For a cleaner and more competitive Europe	Principles/Aims	**Improving product durability**, **eusability, upgradability and reparability**, addressing the presence of hazardous chemicals in products, and increasing their energy and resource efficiency;	**Increasing recycled content** in products, while ensuring their **performance** and safety;	**Enabling remanufacturing** and high-quality **recycling;**	**Reducing carbon** and environmental footprints;	**Restricting single-use** and countering premature obsolescence;	**Introducing a ban** on the destruction of unsold durable goods;	**Incentivising product-as-a-service** or other models where producers keep the ownership of the product or the responsibility for its performance throughout its **lifecycle;**	**Mobilising the potential of digitalisation** of product information, including solutions such as digital passports, tagging and watermarks;	**Rewarding** products based on their different sustainability performance, including by **linking high performance levels to incentives.**
Circle Economy	2019	The Circular Economy GAP Report	Key Elements/Strategies	**Design for the future**: Adopt a systemic perspective during the design process, to employ the right **materials for appropriate lifetime** and extended future use.	**Incorporate digital technology**: Track and **optimise resource use** and strengthen **connections between supply-chain actors** through digital, online platforms and technologies.	**Sustain & Preserve What's Already There:** Maintain, repair and upgrade resources in use to maximise their lifetime and give them a second life through take-back strategies, where applicable.	**Rethink the business model:** Consider opportunities to **create greater value** and align incentives through business models that build on the **interaction between products and services.**	**Use waste as a resource:** Utilise waste streams as a source of secondary resources and **recover waste for reuse and recycling.**	**Prioritise regenerative resources:** Ensure renewable, reusable, non-toxic resources are utilised as materials and energy in an efficient way.	**Team up to create joint value:** Work together throughout the supply chain, internally within organisations and with the public sector to increase transparency and create shared value.		
European Investment Bank	2019	The Circular Economy Guide: Supporting the Circular Transition	Key Strategies	**Reduce/Eliminate:** Design out of Waste	**Reuse** of the product	**Repair:** Recover the producte to an usabe state	**Refurbish**: to recover the used product to a specified quality level	**Remanufacture:** revocer de used product to the quality level of a new product	**Repurpose:** to adapt the used product or part of it to be reused in a different function	**Recycle:** to recover material or components (expect energy) to be reused	**Recover:** (Other recovery processes e.g. bio-resources, wastewater, carbon, energy) - Conversion - Digestion - Treatment	

Assumptions taken from the literature to calculate the stock of materials in buildings

1 for detached houses, 2 for row houses, 3 for apartment buildings and 4 for high-rise buildings.

Region	Building types	Steel	Concrete	Wood	Copper	Aluminium	Glass
11	1	47.90*	1507.04*	77.29*	3.11*	0.93*	2.51*
11	2	24.63*	796.02*	35.77*	0.01	0.23*	1.07
11	3	76.24*	567.99*	49.88*	0.15*	0.46	11.21*
11	4	142.30*	850.70*	27.00*	0.01*	2.20	4.75*

Source: Maroniva et al. (2020)

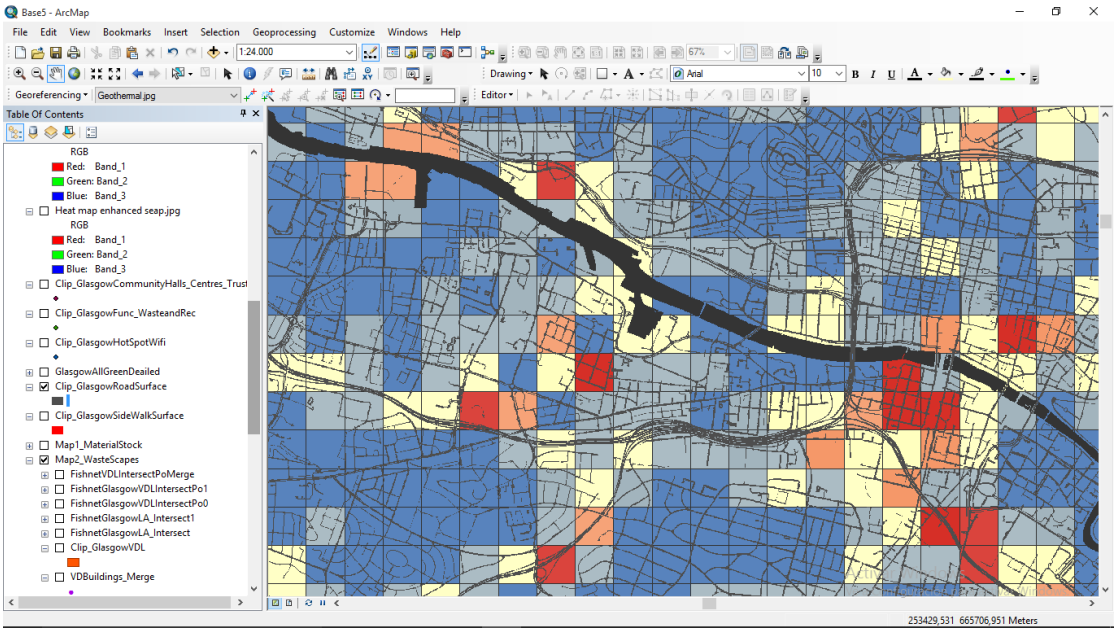
	Source	Description	Region	Steel	Concrete	Aluminium	Copper	Wood	Glass
Offices	Ecoinvent [34]	Multi-storey building	-	24	393	8.5	8.5	24.7	3.1
	Kashkooli [35]	High-rise office building	Mexico	124	425		2.7	3.0	1.0
	Kofoworola [36]	Typical office building	Thailand	256	2118	0.3		1.5	9.6
	Oka [37]	Offices	Japan	158					
	Reyna [38]	Offices (low & high)	USA	42	533	9.7		0.2	4.6
	Schebek [39]	Offices	-	87	1057	0.6	0.7	4.2	13.9
Retail+	**Ecoinvent [34]**	**Hall-type building**	-	**26**	**785**	**1.2**		**18.2**	**1.8**
	Reyna [38]	**Warehouse, department store & small store**	**USA**	**83**	**658**	**2.1**			**1.9**
	Schebek [39]	**Warehouse**	-	**85**	**349**	**1.1**	**0.7**	**4.2**	**13.9**
	Gruhler* [40]	**Wholesale & Car-shop**	**Germany**	**121**	**1009**	**5.2**	**3.9**	**11.0**	
Hotels+	Reyna [38]	Hotel	USA	89	93	5.2			2.7
	Rossello-Batle [41]	Hotel	Spain	51	1007	3.0	3.3	12.0	5.1
	Gruhler* [40]	Hotel/ guesthouse	Germany	113	1073	4.9	3.7	25.0	
Other	**Kumanayake [42]**	**University**	**Sri Lanka**	**132**	**1543**	**5.0**			**7.6**
	Reyna [38]	**School & Hospital**	**USA**	**132**	**835**	**7.9**			**4.9**
	Gruhler* [40]	**Nursing-home & Emergency services**	**Germany**	**104**	**1037**	**4.5**	**3.4**	**25.5**	
	Marcellus-Zamora [43]	**Civic/ Institutional**	**USA**	**40**	**702**				**31.0**
Average				**97.9**	**850.9**	**4.2**	**3.3**	**11.8**	**7.8**

Source: Deetman et al. (2020)

Retail and commercial services considered as circular businesses:

Type
Electrical equipment repair and servicing
charity shops
Vehicle hire and rentals
Tailoring and clothing alteration
secondhand vehicles
Shoe repair
Recycling, reclamation and disposal services
Scrap metal dealer and breakers yards
Industrial repair servicing
Restoration and preservation (construction)
Household goods repair and restoration
Secondhand goods
clearance and salvage dealers
Tools repairs
Rag merchants
Industry equipment repair
Renting and leasing of personal goods
Clothing Hire
Construction and tool and kip hire
Gardening, Landscape and tree surgery
Green and New Age goods
Farm shops and pick your own
Linen hire and washroom services

Screenshot of the grid used for the spatial analyses:



List of neighbourhoods considered for the analysis at that scale.

FID	Name
1	Greater Govan
2	Ibrox / Kingston
3	Greater Gorbals
4	Govanhill
5	Toryglen
6	Shawlands / Strathbungo
7	Langside / Battlefield
8	King's Park / Mount Florida
9	Cathcart / Simshill
10	Croftfoot
11	Riddrie / Cranhill
12	Dennistoun
13	Haghill / Carntyne
14	Blairdardie
15	Yoker / Scotstoun
16	Easterhouse
17	Ruchazie / Garthamlock
18	Temple / Anniesland
19	Knightswood
20	Castlemilk
21	Carmunnock
22	Blackhill / Hogganfield
23	Sighthill / Roystonhill / Germiston
24	Springburn
25	Robroyston / Millerston
26	Balornock/ Barmulloch
27	Parkhead / Dalmarnock
28	Calton / Bridgeton
29	City Centre / Merchant City
30	Hillhead / Woodlands
31	Yorkhill / Anderston
32	Hyndland / Dowanhill / Partick East
33	Broomhill / Partick West
34	Anniesland / Jordanhill / Whiteinch
35	Lambhill / Milton
36	North Maryhill / Summerston
37	Kelvindale / Kelvinside
38	Ruchill / Possilpark
39	Maryhill Road Corridor
40	Drumchapel
41	Springboig / Barlanark
42	Baillieston / Garrowhill
43	Newlands / Cathcart
44	Pollok
45	Priesthill / Househillwood
46	South Nitshill / Darnley
47	Pollokshaws / Mansewood
48	Arden / Carnwadric
49	North Cardonald / Penilee
50	Corkerhill / North Pollok
51	Crookston /South Cardonald
52	Bellahouston / Craigton / Mosspark
53	Pollokshields West
54	Pollokshields East
55	Mount Vernon / East Shettleston
56	Tollcross / West Shettleston