Planning for Circular Cities

The Integration of Circular Economy in Urban Policies and Plans

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Bologna
University Press

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

DIPARTIMENTO
DI ARCHITETTURA

Il volume è stato pubblicato con il contributo dell'Alma Mater Studiorum - Università di Bologna e del Dipartimento di Architettura dello stesso Ateneo

Collana del Dipartimento di Architettura – DA
Dottorato in Architettura e Culture del Progetto
Alma Mater Studiorum – Università di Bologna
Direttore del Dipartimento: Fabrizio Ivan Apollonio

Tutti i contributi pubblicati all'interno della Collana sono sottoposti a un processo di *double-blind peer review*.

Fondazione Bologna University Press
Via Saragozza 10, 40123 Bologna
tel. (+39) 051 232 882
ISSN 2385-0515
ISBN: 979-12-5477-800-5
ISBN online: 979-12-5477-801-2
Doi: 10.30682/9791254778012

www.buponline.com
info@buponline.com

In copertina: immagine realizzata dall'Autore
Progetto grafico: Gianluca Bollina-DoppioClickArt (Bologna)
Impaginazione: Oltrepagina (Verona)
Prima edizione: maggio 2026

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Summary

Access versus ownership
In a circular economy, biological materials are the only ones that can be thought of as consumable, while technical materials have to be used. For this reason, there is no reason to consume technical materials in the same way as biological materials. It is the access to services like cars, washing machines that should be fostered, rather than owning one of them.

Biological materials
Materials that can safely re-enter the natural world, once they have been consumed in one or more use-cycles, where they will biodegrade over time, returning the embedded nutrients to the environment.

Cascades
Cascades is the looping process of biological materials and refers to the process of putting used materials and components into different uses and extracting, over time, stored energy and material order. Along the cascade, this material order declines until the material ultimately needs to be returned to the natural environment as nutrients. A cascade, for example, might be a pair of cotton jeans being turned into furniture stuffing and then into insulation material before being anaerobically digested so that it may be returned to the soil as nutrients.

Green and Blue Infrastructure (GBI)
A strategically planned network of natural and semi-natural areas designed and managed to deliver a wide range of ecosystem services, while also enhancing biodiversity. Such services include, for example, water purification, improving air quality, providing space for recreation, as well as helping with climate mitigation and adaptation. This network of green (land) and

blue (water) spaces improves the quality of the environment, the condition and connectivity of natural areas, as well as improving citizens' health and quality of life. Developing green infrastructure can also support a green economy and create job opportunities. Examples are diverse mixed forests, well-designed urban green spaces, restored wetlands.

Maintain/prolong
It is the action that keeps material and products in use by prolonging their lifespan for as long as possible. It is possible starting from the design phase conceiving products for durability as well as maintenance and repair. These products can be shared amongst users who are able to enjoy the service they provide instead of owning the product itself.

Nature-Based Solutions (NBS)
Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions.

Secondary/non virgin material
Products and materials that have been previously used, including those that are reused, repaired, refurbished, remanufactured, and recycled.

Technical materials
Materials that cannot re-enter the environment like metals, plastics, synthetic materials. These materials must continuously be cycled into the system so as to capture and re-capture their value.

Reuse/redistribute
It is the reuse of products and materials multiple times and the redistribution to new users in their original form or with little enhancement or change. Marketplaces are examples of this approach.

Remanufacture
It is a process of restoring value to a product. When a product is remanufactured, it is disassembled to the component level and rebuilt (replacing components if necessary) to as-new condition and with the same warranty as a new product.

Refurbish
The concept is similar to the remanufacture one, giving new value to a product. However, the refurbishment is a slightly different process since it consists in repairing the product as much as possible usually without disassembly and replacement of components.

Recycle
Recycling is the process of reducing a product to its basic material level, allowing those materials (or a portion of them) to be remade into new products. In the framework of circular economy, recycling practices are essential, however the process is linked with costs to remake products entirely, a loss of materials. For these reasons, it is a lower value process than the reuse and remanufacturing ones.

Virgin material
Material that has not been previously used or consumed, or subjected to processing other than for its original production. May also be called 'raw' or 'primary' materials.

INTRODUCTION

Resource scarcity and climate change represent two of the most pressing challenges of our time. Current estimates indicate that humanity would require approximately 1.7 Earths to provide the resources consumed annually and to absorb the waste generated, resulting in an ecological overshoot day that occurs progressively earlier each year. In 2024, humankind exhausted the planet's annual regenerative capacity in roughly seven months, meaning that the remaining months were spent drawing on ecological debt (York University Ecological Footprint Initiative & Global Footprint Network, 2021). If current trends continue, by 2030 more than two planets would be required to sustain prevailing consumption patterns. Moreover, if the global population were to adopt lifestyles comparable to those of European citizens, demand would rise to the equivalent of three Earths in order to compensate for the imbalance between the global ecological footprint and planetary biocapacity (ibid.). According to the Global Footprint Network, only a limited number of countries worldwide are currently able to meet the basic conditions for sustainable development by simultaneously ensuring socio-economic well-being and environmental sustainability, and these countries are predominantly located in Pacific Asia and the Middle East (ibid.).

Over the past 150 years, industrialisation, deforestation, and large-scale agriculture have expanded exponentially, leading to unprecedented levels of greenhouse gas emissions (United Nations website). Scientific evidence has firmly established a direct link between these emissions and the observed increase in average global temperatures. Carbon dioxide, which accounts for approximately two-thirds of total greenhouse gas emissions, is the most prevalent of these gases and is primarily generated through the combustion of fossil fuels. Since the Industrial Revolution, atmospheric concentrations of greenhouse gases

have risen steadily, driving continuous global warming. Human activity has been identified as the dominant cause of these increases since the 1970s, contributing to changes in the frequency and intensity of extreme events such as heatwaves and droughts. In the absence of policies capable of regulating global economic growth and promoting less energy-intensive lifestyles, carbon dioxide emissions could double by the end of the century, with average global temperatures exceeding 4°C and causing catastrophic consequences for ecosystems and human societies (IPCC, 2023).

Within this context of profound uncertainty, cities are increasingly recognised as key actors in addressing socio-economic and environmental challenges, being "big enough to make a difference but small enough to make it happen" (Resourceful Cities Network, 2022). On the one hand, cities generate approximately 80% of global gross domestic product and act as engines of innovation and economic growth (World Bank, 2023). On the other hand, they are responsible for nearly 75% of global energy consumption and material flows (United Nations Environment Programme & International Resource Panel, 2013), produce around 70% of global waste, and account for approximately 70% of greenhouse gas emissions, despite occupying less than 3% of the Earth's surface (Mukim & Roberts, 2023; OECD, 2020). Challenges such as urban sprawl, resource overconsumption, escalating carbon dioxide emissions, dependence on fossil fuels and scarce materials, waste generation, and adaptation to climate change impacts have therefore become central priorities for public authorities seeking new paradigms to guide urban development towards more resilient and future-proof trajectories.

For several decades, particularly since the early 1990s, sustainable development has been the dominant paradigm for addressing environmental and climate-related challenges. This concept has shaped a development pathway defined as meeting "the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). Two decades later, the Rio+20 Conference marked the emergence of the green economy concept, which was promoted as both a pathway towards sustainability and a response to interconnected climate, financial, and resource crises (Bern-

stein, 2013; UNEP, 2011; World Bank, 2012). The green economy draws upon theories from environmental and ecological economics and is closely associated with cleaner production, resource efficiency, waste hierarchy principles, and industrial ecology. These approaches aim to generate environmental, social, and economic benefits, including climate change mitigation, reduced emissions and biodiversity loss, improved public health, enhanced economic growth, and increased resilience to natural hazards (Loiseau et al., 2016). In urban contexts, the green economy has been interpreted as a framework capable of integrating smart city agendas with eco-urbanism (Caprotti, 2020).

Despite these ambitions, growing empirical evidence suggests that economic growth rarely leads to reduced environmental impacts or effective poverty alleviation (Lorek & Spangenberg, 2014). As a result, the green economy has been criticised for its limited effectiveness in challenging business-as-usual development models and for revealing the difficulties of achieving sustainability through economic mechanisms alone (Schulz & Bailey, 2014).

Against this backdrop, the circular economy has increasingly been recognised as one of the most comprehensive approaches for enabling a paradigm shift towards sustainability, with the potential to reverse ecological overshoot (Circle Economy, 2023). The circular economy seeks to overcome the linear take–make–dispose economic model by maintaining materials, products, and resources within closed-loop systems, thereby eliminating waste and reducing negative externalities. Through the progressive abandonment of linear consumption patterns, the circular economy aims to reduce material use, redesign products and processes to be less resource-intensive, and reintroduce waste as a valuable input for new production cycles. Although the circular economy has gained widespread attention only in recent years, its potential contribution to climate mitigation strategies has been acknowledged by the IPCC. Central to the circular economy are the efficient management of resources, the extension of product lifespans, and the prioritisation of reuse, repair, and remanufacturing. Recycling is considered a last-resort strategy, distinguishing the circular economy from traditional recycling-based economies, which often rely on

downcycling processes that reduce material quality and value (Ellen MacArthur Foundation, 2013, 2015). Instead, the circular economy promotes upcycling practices and eco-effective design, fostering cradle-to-cradle material metabolisms. According to the Ellen MacArthur Foundation, the circular economy is grounded in three core principles: eliminating waste and pollution; circulating products and materials at their highest value; and regenerating natural systems.

Initially promoted through policy initiatives in China, the circular economy gained significant momentum in Europe from the 2010s onward, largely due to the influential work of the Ellen MacArthur Foundation[1]. The concept has also been incorporated into the United Nations sustainable development agenda, where the circular economy is recognised as a key focus area within the Sustainable Development Goals. Nevertheless, the Circularity Gap Report consistently demonstrates that the global economy remains far from circular. The proportion of materials re-entering economic cycles after their first use continues to decline, while extraction rates remain high, indicating a persistent reliance on virgin resources. Between the adoption of the Paris Agreement in 2016 and COP26 in Glasgow in 2021, more than half a trillion tonnes of virgin materials were consumed globally, far exceeding planetary safety thresholds and underscoring the unsustainable nature of current economic systems (Circle Economy, 2023).

Although the circular economy was initially conceived for application within specific economic sectors, both researchers and policymakers increasingly recognise the benefits of scaling its principles to larger spatial dimensions, particularly cities and regions. This shift is especially urgent given that approximately 66% of the world's population is expected to reside in urban areas by 2050 (UN DESA, 2019). Consequently, there is a growing need to develop new urban development frameworks that enable cities to prosper without undermining the planet's regenerative capacity. In this context, the circular city paradigm has emerged as a holistic and systemic response to contemporary urban challenges (Ellen MacArthur Foundation, 2017; Krysovatyy, Zvarych & Zvarych, 2018).

As a direct extension of the circular economy, the circular city concept inherits much of its conceptual ambiguity. The cir-

cular economy itself has been defined in numerous ways, often reflecting divergent and sometimes misleading interpretations. Not all definitions frame the circular economy as a systemic transformation, and many prioritise economic prosperity while overlooking social dimensions (Kirchherr, Reike & Hekkert, 2017). As an evolving concept, the circular economy may never achieve a single, universally accepted definition (Kirchherr et al., 2023). This conceptual uncertainty is mirrored in attempts to scale the circular economy to urban and regional contexts, resulting in multiple interpretations of what constitutes a circular city. Consequently, no shared or consolidated definition of the circular city currently exists.

In Europe, initiatives labelled as circular cities began to emerge in response to European Commission policies promoting circularity. The conceptual flexibility of the circular economy has enabled a proliferation of local experiments across diverse sectors and fields of application, reflecting the fact that circularity often holds different meanings for different actors and stakeholders (Rapoport, 2014). However, many urban circular strategies tend to prioritise the development of circular economy-related businesses rather than supporting a comprehensive systemic transition. Waste management and the closure of selected material flows frequently dominate circular city agendas, while broader socio-spatial transformations receive less attention. As a result, the translation of circular economy principles into urban policy and practice remains fragmented, reflecting the absence of a holistic and operational framework to support policymakers in planning circular urban environments (Marjanović et al., 2022; Millar, McLaughlin & Börger, 2019; Moreau et al., 2017; Sánchez Levoso et al., 2020). Furthermore, Papageorgiou et al. (2021) argue that no comprehensive methodologies currently exist to measure the progress, impacts, and opportunities of circular economy strategies in cities. Policymakers are therefore still grappling with how to translate circular economy theory into tangible spatial transformations. A renewed and expanded interpretation of the circular economy, extending beyond material flow management and waste reduction, is urgently required (Zoboli et al., 2019).

In this context, the pivotal role of spatial planning in facilitating the transition towards circular cities is increasingly rec-

ognised (Fusco Girard & Nocca, 2019; Turcu & Gillie, 2020; van der Leer, van Timmeren & Wandl, 2018; Williams, 2020, 2023). Circular processes and synergies ultimately materialise within physical space, and urban planning instruments represent key mechanisms for shaping urban form, land use, and governance structures. When informed by circular economy principles, spatial planning can act as a powerful enabler of systemic urban transformation towards circularity. Despite numerous scholarly efforts to conceptualise the circular city in a holistic manner, explicit engagement with spatial planning remains limited. Consequently, a comprehensive framework capable of supporting decision-makers in integrating circular economy principles into spatial planning tools and practices is still lacking.

The research overall aims at overcoming this gap by answering the main research question that is *how to integrate the circular economy principles into urban planning tools in order to foster circular urban development*. To answer this comprehensive question, four specific sub-questions have been pointed out.

Sub-question 1:
To what extent CE (Circular Economy) is embedded into current international and EU strategies and into urban planning policies and practices at different territorial levels?

Sub-question 2:
What does circularity mean if applied to cities according to an urban planning perspective?

Sub-question 3:
Which are the available instruments to integrate circularity principles into urban policies and strategies?

Sub-question 4:
How to fill the gaps to support policy-makers in planning circular cities?

Firstly, in order to plan for circular cities, there is the need to understand which are the policies fostering the transition towards the new paradigm (sub-question 1). Not only does this help identify the main focus areas, but it also allows us to assess whether the role of the circular economy in the transition has already been integrated into European and international policies, and whether the role of urban areas is recognised.

The second sub-question allows us to frame the circular city concept, since it is essential to interpret it according to an urban planning perspective if the overall goal is to plan for it.

Lastly, the recognition of the available instruments, schools of thought, focus areas (sub-question 3) is important to understand the current gaps and propose a methodology that aims at supporting decision-makers in planning for circular cities (sub-question 4).

Given the strong multi-disciplinarity of circular economy, the research also demonstrates the role of spatial planning in combining multiple challenges and approaches coming from different disciplines and fields. All of them can be integrated into the discipline to concur in increasing urban quality and liveability. In this specific case, circular economy enters the urban planning discourse, and the outcome of this research supports this integration in becoming effective.

Note

[1] https://www.ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview

RELEVANCE AND STRUCTURE OF THE BOOK

As mentioned, the overall aim of the book is to contribute to the discussion about the importance of integrating circular economy principles into urban planning discipline, if the effective transition is to be implemented. On the one hand, the goal is to provide a spatial-planning oriented vision of the circular city easy to understand by policy makers and able to guide urban strategies for cities' regeneration and transformation. On the other hand, the proposed vision is also embedded into existing procedures (and namely the Strategic Environmental Assessment) demonstrating how to guide policy makers towards the integration of circularity in drafting their urban plans.

This section aims at highlighting how the goal has been achieved in terms of process and methodology. The first two chapters of the book are focused on understanding. To understand the strength and the relevance of the concept, Chapter 1 is analysing the circular economy policy framework at both international and European level. In fact, the presence of policies that support a paradigm shift is key for its success and its effective applicability, also given the financial support that may arise from this. Since circular economy is inserted into the global context of sustainable development, the most important documents enacted respectively at international and European levels targeting sustainability are analysed to understand if circular economy is acknowledged. At the same time, for those policies that are directly targeting circularity, the analysis has aimed at understanding whether the role of urban areas and spatial planning is recognised as fundamental into the transition. However, circular economy transition can happen at lower level of governance and European and global policies have to be transposed into Member States legislations. Therefore, a focus on a lower scale is performed, and examples of circular economy policies at Italian level are provided with regional in-depth

research into the Emilia-Romagna region. Indeed, this latter is a virtuous and interesting example since it included circular economy into the regional strategy for sustainable development and into its smart specialization strategy.

After this detailed context analysis, the passage of scale from the circular economy to the circular cities theories has been investigated. Their origins and the many definitions are mapped thanks to a literature review, accompanied by the study of two exemplary cases to enrich the picture from the practical point of view. The two case studies presented in Chapter 2 have been selected given the role they played into the European context: the first one is Amsterdam, as a frontrunner city in embracing circular economy, while the second one is Prato as Italian leader in the Urban Agenda partnership for Circular Economy.

This analysis of the multi-faceted state of the art is composing a first block of the book that, in terms of methodology, makes an extensive use of the scientific literature review, used as the main method of investigation. In the case studies analysis, the review has been made through report analysis and direct experiences on the field in the case of Amsterdam.

The following chapters of the book are embracing a shift into the perspective: from the generic interpretation of the circular city, the research now aims at focusing on the topic from an urban planning point of view, that will lead to the definition of a methodological framework to plan for circular cities. After having investigated the potential role of urban planning in fostering a circular urban development, Chapter 3 presents the pillars for planning circular cities through the use of a systematic literature review made on Scopus and Web of Science databases. The review is aiming at identifying the existing research trends in the application of the circular economy at urban scale and in urban planning, in the attempt to systematize the existing and still evolving knowledge in the field. The most holistic urban circularity frameworks are discussed, with the purpose to understand which of the existing methodologies are available to interpret circularity at city level and according to an urban planning perspective.

By building on the lessons learned from the literature review, an innovative proposal is conceived and presented targeting spatial framework plans. Starting from the explicit links among the analysed frameworks and the important role of spa-

tial planning in enabling a holistic transformation of the city towards circularity, an innovative approach to build the circular city is proposed. Chapter 3 concludes with the identification of guiding principles, to inspire this vision.

Chapter 4 presents how the approach to the circular city is embedded into a tool that is already in force in all European member States: the Strategic Environmental Assessment (SEA). Indeed, this procedure can become a decision-support system if used to accompany the spatial framework plans from their first conceptualization. After an overview of the SEA procedure, as included into the European Directive, key steps to integrate circularity into SEA process are presented, thus preparing a decision-making framework in support of plan-makers.

Chapters 5 and 6 dive into the details of the SEA steps and present how to interpret and enrich them according to a circular-inclusive perspective. In detail, a proposal of strategic objectives for spatial plans and indicators for monitoring the transition and the implementation of urban projects is provided, to make the transition as operational as possible.

Both guiding principles and strategic objectives have been validated with experts in circular economy and policy-makers through an online survey launched with the aim to collect their opinions and feedback, they being the final target users of the proposed methodology.

Finally, the conclusions wrap up the outcomes of the research and present recommendations for future work.

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1. TOWARDS CIRCULAR CITIES: AN EVOLVING CONCEPT FOR A (NEW?) PARADIGM OF SUSTAINABILITY

1.1. Cities as an evolving concept

Urban policies and strategies have evolved in response to the global challenges that cities face in their efforts to improve the quality of life of their inhabitants. Climate change mitigation and adaptation represent some of the most pressing contemporary issues confronting urban authorities. As a result, cities are increasingly undergoing transformation processes and adopting visions that respond to global environmental, social, and economic dynamics. Over time, planners and policymakers have translated these influences into the formulation of urban paradigms. Urban paradigms can be understood as "urban dreamscapes, full of wishful thinking about better urban worlds" (Kunzmann, 2014). A paradigm becomes meaningful when it can be translated into a specific and recognisable urban development trajectory that differentiates it from others (De Jong et al., 2015).

Today, numerous urban paradigms coexist and frequently overlap in both theory and practice. Concepts such as smart cities, resilient cities, creative cities, regenerative cities, green cities, knowledge cities, eco-cities, and low-carbon cities have gained prominence over the past two decades. Because these paradigms share common conceptual foundations, policymakers, planners, and developers often use them interchangeably. Broader ideas such as sustainable development, ecological modernisation, and regenerative development influence all these paradigms and generate significant conceptual overlap and cross-fertilisation (De Jong et al., 2015).

The origins of contemporary urban paradigms can be traced to the 1970s and 1980s, when the oil crises revealed the finiteness of natural resources and scientific research began to quantify the environmental and health impacts of rising air pollution

levels. During this period, sustainable development emerged within environmental planning and progressively gained importance in public policies. In urban planning, this awareness was translated into strategies aimed at reducing local pollution, limiting urban sprawl, and addressing traffic congestion (Zhou & Williams, 2013). The publication of the Brundtland Report and the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992 brought the concept of sustainable development to global attention and firmly embedded it in urban strategies and policies. These priorities continue to represent central concerns for many city governments. Eco-cities, low-carbon cities, and green cities developed primarily in response to these sustainability challenges.

From the early 2000s, increased attention to climate change expanded urban policy agendas beyond environmental protection and social well-being to include adaptation to global climate change and resilience to natural disturbances. Resilient city policies emerged to address both natural and human-induced hazards and share several conceptual foundations with sustainable and eco-city approaches (Zhou & Williams, 2013).

During the same period, digitalisation began to profoundly influence citizens' behaviours, expectations, and needs. The first smart city initiatives appeared in the late 1990s under the concept of digital cities, which highlighted the role of local information and communication technology networks in fostering new forms of virtual community. This initial digital paradigm evolved into concepts such as information cities, ubiquitous cities, and intelligent cities, which gradually expanded to include governance, infrastructure, and social dimensions. Rather than developing in opposition to eco-urban ideals, the smart city paradigm integrated sustainability objectives into its framework. The notion of the smart eco-city emerged as an approach to achieve environmental goals through technology-enabled urban strategies (Caprotti, 2020).

A bibliometric review conducted by De Jong et al. (2015) identified several urban paradigms, including sustainable cities, eco-cities, low-carbon cities, smart cities, knowledge cities, and resilient cities, as conceptually distinct and supported by specific theoretical foundations. Among these, the sustainable city emerged as the most central and recurrent paradigm, function-

ing as an umbrella concept capable of addressing the ecological, economic, and social dimensions of sustainable development. However, the broad scope of the sustainable city paradigm contributed to the growing popularity of more narrowly defined concepts, particularly low-carbon cities and smart cities.

Low-carbon and climate-neutral cities are primarily characterised by their focus on reducing and eliminating greenhouse gas emissions, especially carbon dioxide. Achieving these objectives requires interventions across multiple urban sectors, including transport, the built environment, and agriculture, which are all significant sources of emissions. The eco-city paradigm places greater emphasis on achieving balance with natural systems by promoting compact urban forms, cleaner transport solutions, and the regeneration and protection of ecosystems.

The smart city paradigm is widely regarded as an evolution of earlier digital, information, and intelligent city models (De Jong et al., 2015; Winkowska, Szpilko & Pejić, 2019). By 2013, the term smart city had surpassed sustainable city in academic literature (De Jong et al., 2015). Environmental sustainability and quality of life objectives are increasingly integrated into smart city strategies, while the defining feature of this paradigm remains the central role of digital and smart technologies in enabling urban services and governance. This interpretation is reinforced by the International Organization for Standardization through the publication of ISO 37122 on indicators for smart cities under the framework of sustainable cities and communities, together with ISO 37120 on indicators for city services and quality of life (BSI Standards, 2019).

The resilient city paradigm is grounded in an understanding of resilience that extends beyond resistance to shocks. Resilience also refers to the capacity for adaptation, learning, and system transformation following disturbances (Folke, 2006). In urban studies, resilience is closely associated with the capacity to cope with climate change impacts, natural hazards, and disasters (Meerow, Newell & Stults, 2016). The OECD defines resilient cities as urban systems capable of maintaining essential functions and meeting the primary needs of communities during periods of stress or shock, while ensuring rapid recovery through the effective management of both physical and social infrastructure. The distinctive feature of resilient cities

lies in their ability to adapt to risks through flexible planning and integrated hazard management.

In recent years, the circular city has begun to emerge as a new urban paradigm. This concept derives from circular economy theories, which promote a shift from linear models of production and consumption towards circular systems that minimise waste and optimise resource use. The circular economy tackles climate change and other global challenges, like biodiversity loss, waste, and pollution, by decoupling economic activity from the consumption of finite resources. Numerous efforts have been made to translate circular economy principles to urban and regional scales, giving rise to the circular city paradigm. Whether the circular city will become the next dominant paradigm for urban sustainability and address emerging challenges such as pandemics and increasingly severe climate change impacts remains uncertain. Given the novelty of the concept and its ongoing development, it is still premature to assess its long-term influence on urban transformation. Nevertheless, an increasing number of cities are experimenting with circular strategies and implementing structured policies to support this emerging paradigm.

1.2. The growing interest in the circular economy in cities

Over the last decade, the circular economy has progressively gained prominence within international, European, national and regional policy frameworks as a strategic approach to address sustainability, climate change, resilience and resource scarcity, with cities increasingly recognised as key arenas for its implementation. Although no binding international policy explicitly targets the circular economy as a standalone objective, its principles are widely embedded in global sustainability agendas, most notably within the United Nations framework and the work of the OECD. At the global level, the 2030 Agenda for Sustainable Development does not explicitly mention circular economy, yet many of its SDGs are implicitly aligned with circularity through goals related to responsible consumption and production, climate action, sustainable cities and the protection of ecosystems. The New Urban Agenda represents a further step

in this direction by explicitly promoting the transition towards a circular economy within the context of environmentally sustainable and resilient urban development, while emphasising the role of urban spatial planning, multilevel governance and the integration of climate mitigation and adaptation into urban policies. In parallel, OECD and UNECE initiatives have contributed to consolidating the understanding of circular economy as a systemic transformation that extends beyond recycling practices and encompasses urban services, infrastructure, land use, governance models and behavioural change. These contributions stress that cities can act as promoters, facilitators and enablers of circularity by closing material loops, avoiding linear lock-ins in infrastructure systems and fostering functional relationships between urban and rural areas.

At European level, the circular economy becomes more explicitly articulated within policy-making, particularly through the European Green Deal and the two Circular Economy Action Plans adopted in 2015 and 2020. The European Green Deal establishes the overarching vision of decoupling economic growth from resource consumption and achieving climate neutrality by 2050, positioning circular economy as a foundational mechanism to reduce environmental pressures, support biodiversity and enhance competitiveness. The first Circular Economy Action Plan laid the groundwork by introducing measures across the entire life cycle of products, from production and consumption to waste management and secondary raw materials markets, while also initiating a common monitoring framework to assess progress. Its implementation has contributed to measurable improvements in recycling rates, innovation and employment in circular sectors, even though challenges remain in reducing overall consumption levels and increasing the use of secondary raw materials. Building on these results, the New Circular Economy Action Plan further strengthens the role of circularity within European policy, introducing actions that explicitly acknowledge the contribution of people, regions and cities to the transition. While not all sectors directly address the urban scale, particular relevance is attributed to the built environment, construction and demolition waste, land use and urban regeneration, with initiatives such as the proposed strategy for a Sustainable Built Environment and the Renovation Wave highlighting the poten-

tial of circular principles in reshaping cities. European initiatives such as the Circular Cities and Regions Initiative, the Intelligent Cities Challenge and the Circular Economy Stakeholder Platform further support cities through funding, knowledge exchange and networking, reinforcing the idea that local contexts are essential for effective implementation.

The growing interest in circular economy at urban level is also reflected in national and regional policies, as illustrated by the Italian case. Italy has progressively aligned its national strategies with European and global sustainability agendas, particularly through the National Strategy for Sustainable Development and the National Strategy for Circular Economy. These documents frame circular economy as a comprehensive socio-economic transition that integrates environmental protection, economic competitiveness and social inclusion, while emphasising territorialisation as a cornerstone of implementation. Regions and local authorities are therefore called upon to adapt national objectives to local contexts and to play an active role in achieving sustainability goals. Within this framework, urban areas are explicitly recognised as strategic spaces where circular principles can be translated into concrete actions related to resource efficiency, urban regeneration, sustainable mobility, soil protection, industrial symbiosis and participatory governance. The Emilia-Romagna region provides a significant example of this approach, having adopted one of the first regional laws on circular economy in Italy and developed complementary strategic documents that expand the scope of circularity beyond waste management to include prevention, reuse, innovation and job creation. The region's emphasis on ambitious targets, temporary uses of vacant buildings, brownfield regeneration and the reuse of existing urban assets demonstrates how circular economy is increasingly intertwined with spatial planning and urban policy.

Overall, the policy framework reveals a growing and multi-scalar interest in circular economy as a key lever for sustainable urban transformation. While important progress has been made in embedding circular principles within international and European strategies, the analysis also highlights persistent gaps, particularly the limited integration of a holistic urban perspective in some sectoral policies and monitoring frameworks. Nevertheless, the increasing recognition of cities as pivotal

actors in closing resource loops, fostering innovation and enabling systemic change suggests that urban areas are progressively moving to the centre of the circular economy discourse. This evolution confirms that the transition towards circularity is not only a matter of technological solutions or waste management, but a broader transformation of urban systems, governance structures and planning practices, in which cities play a decisive and increasingly acknowledged role.

1.3. The circular city paradigm

At the beginning of this chapter, the circular city is examined as a potential new paradigm for sustainability. As this concept is still relatively recent, its long-term impacts on urban development cannot yet be fully assessed. Nevertheless, both a recognisable theoretical foundation and an emerging policy framework supporting the circular city are already evident. Circular economy theory clearly constitutes the conceptual basis of circular cities, and its role is increasingly acknowledged within international and European policy agendas as a key mechanism for the transition towards sustainability.

Urban paradigms have historically evolved in response to emerging challenges, progressively expanding the scope of urban sustainability. Since the 1990s, paradigms such as sustainable, eco, low-carbon, smart, and resilient cities have shared the objective of capturing and operationalising efforts towards urban sustainable development (De Jong et al., 2015). With the emergence of the circular economy, extending this framework to the urban scale has attracted growing attention, leading policymakers to develop circular agendas to guide long-term urban visions and development strategies (Marjanović et al., 2022; Williams, 2021a). Within this context, the transition from circular economy principles to the circular city has become a central topic of academic debate, prompting reflections on its conceptual foundations and definitions.

The first academic contributions addressing circular economy principles at the urban scale date back to the 1990s, with Girardet's work on circular urban metabolism. These studies focused on resource recycling and ecological balance as fundamen-

tal elements of sustainable cities (Girardet, 1990a, 1990b). In the early 2000s, China became a central reference in this debate through the application of material flow analysis to cities such as Guiyang and Taipei, reinforcing the relevance of urban-scale resource accounting.

In Europe, the circular economy gained prominence more recently, primarily as a policy strategy aimed at transforming environmental constraints into economic opportunities through resource efficiency, innovation, and the valorisation of secondary raw materials (McDowall et al., 2017). At the same time, the concept of the regenerative city emerged in European scholarship as a model promoting circular relations, synergies, and urban symbiosis inspired by natural systems, anticipating key aspects of the circular city (Fusco Girard, 2014a, 2014b). Following the pioneering work of the Ellen MacArthur Foundation and the adoption of the first Circular Economy Action Plan by the European Commission (European Commission, 2015), academic publications on circular cities increased significantly.

Scaling the circular economy from economic systems to cities requires a shift from a predominantly economic focus to a broader socio-ecological perspective (Williams, 2021a). Kirchherr, Reike & Hekkert (2017) contributed to this transition by identifying multiple operational levels of the circular economy, extending from firms to cities, regions, and nations. They explicitly framed the circular economy as a means to achieve sustainable development by simultaneously enhancing environmental quality, economic prosperity, and social equity, supported by innovative business models and responsible consumption practices (Kirchherr, Reike & Hekkert, 2017). Climate change mitigation and adaptation further reinforce the relevance of the circular economy at the urban scale. While the circular economy initially focused on resource scarcity and efficiency, a growing body of literature highlights its contribution to climate objectives, strengthening its applicability to cities (Ellen MacArthur Foundation, 2019; Hoogzaad et al., 2020; Yang et al., 2023).

The social dimension of circular cities has progressively gained relevance. Prendeville, Cherim & Bocken (2018) analysed six cities undergoing circular transitions and conceptualised circular cities as places where circular economy principles are implemented in partnership with local stakeholders. This perspective

positions cities primarily as centres of consumption and emphasises the role of citizens' behaviours, lifestyles, and active engagement in delivering circular outcomes. Despite its importance, the social dimension has often remained marginal in academic research, frequently limited to employment impacts (Vanhuyse et al., 2021). Integrating socio-ecological aspects alongside economic objectives is therefore essential to articulate a holistic concept of the circular city. In this respect, although environmental concerns initially drove circular economy implementation, social and economic motivations are increasingly recognised as central drivers of the transition (OECD, 2020).

The definition of the circular city remains contested and subject to ongoing debate (Nocca & Girard, 2018). A comprehensive review of academic and policy definitions reveals strong convergence around waste reduction, efficient resource use, flexibility of the built environment, cooperation, and recycling. Urban greening and ecosystem regeneration are widely acknowledged, as is the enabling role of digital technologies, which are generally conceived as means rather than ends. Many definitions align with the vision promoted by the Ellen MacArthur Foundation, which frames the circular city as an urban system embedding circular economy principles across all functions, with the aim of eliminating waste, preserving asset value, and enhancing liveability, resilience, and prosperity while decoupling value creation from finite resource consumption (Ellen MacArthur Foundation, 2017).

Until 2018, the relationship between circular cities and quality of life received limited attention in academic literature, while official city documents more frequently emphasised employment, innovation, and liveability. Across both academic and policy definitions, decoupling resource consumption from economic growth emerges as a primary objective (Nocca & Girard, 2018). However, several authors argue that circular cities should be understood as holistic urban transformations rather than as collections of circular economy projects or optimised production–consumption systems (Nocca & Girard, 2018; Williams, 2019; Prendeville, Cherim & Bocken, 2018).

More recent definitions increasingly foreground the social dimension, highlighting stakeholder participation, community engagement, human health, and wellbeing (Birgovan et al.,

2022; Campbell-Johnston et al., 2019; Cottino, Domante & Franchina, 2022; Papageorgiou et al., 2021; Williams, 2021b). Despite this evolution, the closure of resource loops and the transition from linear to circular urban metabolism remain central elements across most definitions (Birgovan et al., 2022; Campbell-Johnston et al., 2019; Canet-Marti et al., 2021; Chang & Chang, 2020; Langergraber et al., 2021; Lucertini & Musco, 2020; Paiho et al., 2020; Prendeville, Cherim & Bocken, 2018; Savini, 2019). Some contributions also stress the continued relevance of economic rationales within circular city strategies (Krysovatyy, Zvarych & Zvarych, 2018; Lakatos et al., 2021; Pintossi, Kaya & Roders, 2021; Savini, 2019). Fusco Girard and Nocca (2019) explicitly frame the circular city as a systemic response to ecological crises and social inequalities, linking environmental sustainability with social justice and highlighting regenerated, accessible, and adaptive urban systems (Fusco Girard & Nocca, 2019; Williams, 2021a).

The most comprehensive interpretations of the circular city embrace sustainable development objectives by addressing finite resource consumption, ecosystem preservation, and regeneration. Through practices such as reuse, sharing, optimisation, and substitution of finite resources with renewable ones, circular cities aim to reduce resource consumption, waste generation, and greenhouse gas emissions while enhancing climate adaptation and urban resilience. From this perspective, the circular city integrates and advances previous urban paradigms.

According to Williams (2023), circular urban development is grounded in three core actions: looping, ecological regeneration, and adaptation. These actions synthesise key elements of earlier paradigms. Looping actions resonate with eco-city and low-carbon city approaches through recycling and recovery practices. Ecological regeneration aligns with eco-city and resilient city frameworks by enhancing ecosystem services and managing environmental risks. Adaptive actions reflect resilient city principles through flexible infrastructures and adaptive communities. Taken together, these dimensions position the circular city as a paradigm capable of integrating and advancing the objectives of previous urban models, offering a systemic framework to address the evolving challenges of contemporary cities.

Tab. 1. Linkages between the Williams' circularity paradigm and other cities' concept. Adapted from (Williams, 2023)

Circular action	Codes	Subcodes	Similarities with
Loop	Reuse	Adaptive reuse, refurbishment, repair, food reuse.	Low-carbon city Eco-city
	Recycle	Composting, landfill mining, urban mining, grey water recycling, black water recycling, circular economy, circular construction.	
	Energy recovery	Waste-to-energy, bio-energy, biofuel, bio-digesters, heat recovery. Waste-heat capture.	
Ecologically regenerate	Infrastructure	Green and blue infrastructure.	Low-carbon city Eco-city Resilient city
	Ecosystem services	Ecosystem services, biodiversity, carbon sequestration, flood management, pollution control, climate regulation; water and nutrient cycles.	
	Ecosystem management	Urban agriculture, urban forestry, conservation, water management, soil management, phytoremediation, bioremediation, land decontamination.	
Adapt	Infrastructure	Adapt, adaptable infrastructure, adaptive design, climate adaptive infrastructure.	Resilient city Smart city
	Communities	Adaptive communities, community engagement, co-provision, cooperatives, transition towns, social enterprises.	
	Urban form	Pop-up spaces, meanwhile spaces, temporary urbanism, temporary uses, climate adaptation.	

This interpretation is also supported by an online survey that has been shared with policy-makers, academia and experts in the circular economy field. 37 responses were collected and participants were asked to provide three keywords to describe the circular city. The two most frequent words associated with circularity have been "sustainable" and "resilient," with a frequency of 13 and 11 respectively. They doubled the third most used keywords that are "efficient" and "regenerative" that have been cited 5 times each. Figure 1 shows the word cloud generated with all the keywords mentioned by participants. This result is supporting the idea that the circular city is a paradigm able to hold together and strengthen the concept of sustainability and resilience, while the role of digital technology is a less established trend from the answers.

As emerged from above, a clear and shared definition of the circular city is still lacking. At the same time, the flexibility of the concept has played a crucial role in supporting its diffusion.

1. Word cloud showing the most frequent words associated with circularity. (Author's elaboration)

This flexibility allows for experimentation and enables multiple interpretations by different actors and stakeholders (Rapoport, 2014). The openness of the concept is reflected in the diversity of strategies, priorities, and drivers adopted by cities that define themselves as circular. This trend indicates that the circular city has become a source of inspiration for policymakers, even if it is often interpreted in partial and context-specific ways (Nocca & Girard, 2018). The analysis of these real-world experiences provides valuable insights into the ways in which ongoing transitions towards circularity are taking shape. It also offers empirical support to urban planning processes that seek to define guiding principles which are achievable in practice (ibid.). In the following chapter, an analysis of the most promising examples of circular cities is therefore conducted, with the objective of also learning from the experience.

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2. LEARNING FROM EXPERIENCE: CIRCULAR CITIES IN PRACTICE

Experiences described as "circular cities" began to emerge in Europe following initiatives promoted by the European Commission that explicitly addressed transitions towards a circular economy. According to Williams (2021), by 2016 several countries had adopted national strategies for the implementation of circular economy principles. These countries included the Netherlands, Scotland, Finland, and Germany. By 2018, additional countries had introduced policies aimed at promoting circular economy approaches. These countries included France, Slovenia, Portugal, Greece, Italy, and Luxembourg. At the urban scale, the New Urban Agenda Partnership on Circular Economy played a significant role in fostering circular transitions. Cities such as London, Paris, and Amsterdam were among the first to formally declare the adoption of circular economy principles in urban development. These early adopters were later followed by a growing number of European cities (ibid.).

In October 2020, a broad coalition of European cities formally committed to circular principles by signing the European Circular Cities Declaration. This event took place during the Ninth European Conference on Sustainable Cities and Towns held in Mannheim. The signatory cities included Tirana, Ghent, Leuven, Mechelen, Prague, Freiburg im Breisgau, Copenhagen, Høje-Taastrup, Roskilde, Helsinki, Lappeenranta, Oulu, Tampere, Turku, Grenoble, Budapest, Florence, Prato, Wiltz, Bergen, Oslo, Guimarães, Ljubljana, Maribor, Seville, Eskilstuna, Malmö, and Umeå. By 2022, the number of signatory cities had increased to seventy-one across twenty-two countries. The Declaration defines a shared vision of the circular city that is centred on resource efficiency, resilience, and inclusiveness. It explicitly aims to decouple economic growth from resource consumption. Among its core commitments, signatory cities are required to define clear circular economy goals and strategies.

They are also required to promote awareness within public administrations and among local stakeholders. Furthermore, they must integrate circular principles into urban planning, infrastructure development, and asset management practices (ICLEI & Ellen MacArthur Foundation, 2022).

Alongside these policy developments, academic research has increasingly focused on the barriers and opportunities associated with urban transitions towards a circular economy. Williams analysed circular development pathways in Paris, London, Amsterdam, and Stockholm. This analysis identified a wide range of implementation challenges together with significant benefits linked to circular strategies (Williams, 2019; Williams, 2021). Similarly, Paiho et al. developed a systematic classification of circular economy-related challenges in cities. Their work identified barriers across business, policy, technical, and knowledge domains (Paiho et al., 2020).

From a governance perspective, one of the most persistent obstacles is the lack of integrated policy approaches. The fragmentation of administrative structures often leads to disconnected strategies that fail to recognise synergies among circular actions. Institutional silos therefore constitute a major barrier to circular urban development. Short political cycles further limit the capacity for long-term strategic planning. Such planning is essential for circular transitions that require deep economic, cultural, institutional, and technological transformations. Political priorities may also conflict with circular objectives. This conflict can restrict the scope for effective implementation. Existing regulatory frameworks are frequently identified as rigid and insufficiently adaptable to support circular practices.

The increasing influence of private actors in economic and societal transformation presents additional challenges for circular transitions. This trend is often associated with a reduced role of the State. In many contexts, private-sector actors prioritise short-term economic returns. This orientation may hinder the adoption of circular strategies that depend on long-term investments and systemic change.

Knowledge-related and cultural barriers further affect the implementation of the circular economy in urban contexts. A widespread lack of awareness often results in limited public par-

ticipation in circular initiatives. Cultural values such as individualism, short-termism, and limited concern for collective wellbeing have been identified as factors that negatively influence circular development (Williams, 2020). Individualism promotes resource-intensive consumption patterns and higher levels of waste generation. It also undermines social capital. Short-termism reduces attention to intergenerational equity and to the preservation of resources and ecosystems. By contrast, values associated with care for people and the environment support responsibility, solidarity, and wellbeing. These values align more closely with circular practices. Cultural perceptions also influence the valuation of circular products and practices. Reused or recycled goods are often perceived as having lower quality, performance, or safety. From a knowledge perspective, both public and private actors frequently lack a clear understanding of circular economy principles and implementation pathways. The circular economy is often narrowly associated with specific sectors such as waste management. Comprehensive systemic perspectives and robust performance indicators for measuring circularity remain underdeveloped.

Economic barriers also play a significant role in limiting circular transitions. These barriers include high initial investment costs, limited access to funding, and insufficient economic incentives to support circular initiatives.

Based on Williams' comparative analysis, several pathways towards circular urban development can be identified. Three approaches emerge most clearly from the practices adopted by leading cities. The first approach is the city-regional pathway. This pathway combines resource flow analysis aimed at closing material loops with strategic programs for adaptive building conversion at the regional scale. It depends on the availability of public land and on comprehensive databases of vacant sites. These tools make it possible to match spatial needs with emerging circular initiatives. The second approach is the temporary-experimental pathway. This pathway enables the testing of circular activities through temporary uses, community engagement, and support for small businesses. Temporary planning permissions play a crucial role in enabling these experimental practices. The third approach is the eco-district pathway. This pathway focuses on the development of new urban areas

designed according to circular principles of resource looping, ecological regeneration, and adaptability. It typically requires substantial public investment, the allocation of public land, and tailored regulatory frameworks due to the large scale of the interventions involved.

Among these pathways, the temporary-experimental approach is particularly innovative. It promotes a vision of circularity that goes beyond the closure of material loops. It actively involves local communities in processes of urban transformation. Urban experimentation challenges conventional regulations and established spatial uses. It does so by proposing alternative models of environmental regeneration and social cohesion (Cuomo et al., 2020). These experimental environments are commonly conceptualised as Urban Living Labs.

Within this framework, Amsterdam represents a particularly significant case study. The city adopts both the city-regional pathway and the temporary-experimental pathway. In Amsterdam, temporary experimentation is implemented through a hybrid approach that combines top-down and bottom-up dynamics. This approach operates at the district scale and is most evident in the area of Buiksloterham in Amsterdam Noord. Another relevant case within the Italian context is Prato. Prato is a frontrunner city within the European Circular Cities Declaration network. It also served as the Italian lead city in the Urban Agenda Partnership on Circular Economy. The city has adopted a circular strategy that is supported by living lab approaches. These approaches are used to strengthen community engagement. For these reasons, both Amsterdam and Prato are examined in greater detail in the following sections.

2.1. Amsterdam as front-runner city in embracing circular urban development

Amsterdam's circular economy policies are heterogeneous and permeate many different sectors, since circular economy has been included in the policy discourse at the beginning of the debate (Cuomo et al., 2020). When it comes to the city-regional pathway, in 2020 the city embraced a circular strategy emphasizing the ambition of becoming fully circular by 2050.

The government adopted a holistic view of circular economy, not only addressing the transition from an economic point of view, but also recognising the linkages between nature-based solutions, natural capital and the resilience of the city to resource scarcity and climate change (Williams, 2021). The Implementation Agenda 2023-2026, published by the Municipality of Amsterdam, and the Amsterdam Circular Strategy 2020-2050 are the main reference documents for the city's circular economy efforts. The Implementation Agenda includes over 70 concrete actions to be realized in collaboration with citizens, businesses, and social initiatives, supported by dedicated funding exceeding 14 million euros. These outcomes have been synthesized in reports offering lessons and recommendations to guide ongoing processes (Gemeente Amsterdam, 2022). The strategy has been focused on three key value chains: food and organic waste, consumer goods and built environment.

In addition, in collaboration with Kate Raworth, the city adopted the City Doughnut model that provides a view of the social and environmental impact at both local and global levels according to the ceilings of nine planetary boundaries. The Doughnut is the basis for the Amsterdam Circular Monitor, a dashboard for monitoring Amsterdam's circularity in terms of material imports, raw material consumption, generated waste and its treatment either in the city or abroad. Both the CO_2 emissions and other ecological impacts of the material flows have been calculated, providing a basis to estimate to what extent the city operates within the planetary boundaries. As a consequence, the monitoring outcomes offer starting points to understand what is needed to make improvements. It has been a first attempt to understand Amsterdam's metabolism as a city. The Circular Economy Monitor is continuously developed to evaluate progress toward the goals of reducing virgin material use by 50% by 2030 and achieving full circularity by 2050.

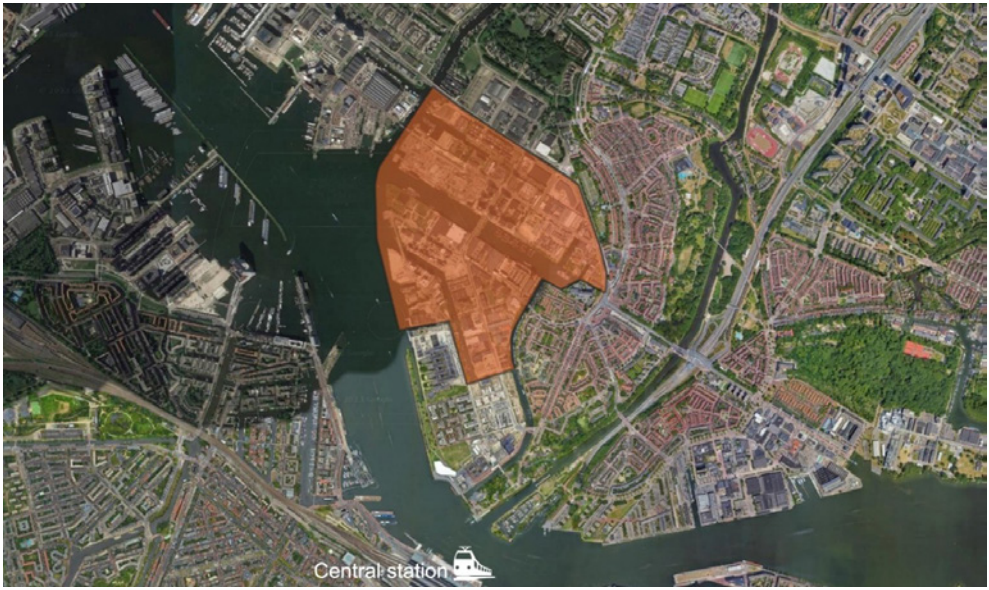
In 2022, the new government coalition integrated circular economy into the coalition agreement for the timeframe 2022-2026. Circular economy is embedded into the more generic sustainability agenda of the city, being one of the three transitions on which the municipality decided to focus together with energy transition and the green transition for a greener and healthier city (Municipality of Amsterdam, 2023). In the vision of

the city the motto is: "move from doing circular things to doing things circularly, applying circular economy principles where it really matters".

On the other side, Amsterdam is also an excellent example of temporary and experimental circular development pathway thanks to the experience of the Buiksloterham district. It is located in Amsterdam Noord neighborhood and the area plays a strategic role in Amsterdam's development strategies, since it is located in proximity to the city centre, on the opposite side of the IJ river, connected to the Central Station with a free ferry of around ten minutes duration (fig. 2). In addition, its accessibility has increased thanks to the construction of the north-south metro line that connects the historic city centre with the northern side of the river.

Buiksloterham has a long-standing industrial vocation, as the majority of its industrial activities emerged at the beginning of the twentieth century and remained in place throughout the entire century. During the 1980s, as many industries relocated elsewhere, the municipality began to reconsider the future development trajectory of the area. The objective was to introduce new functions that could combine industrial activities with residential and working uses. This intention faced significant constraints due to high levels of noise and soil pollution, which strongly limited the feasibility of residential development under existing environmental conditions. At the beginning of the 2000s, Amsterdam was experiencing rapid demographic growth, with an average increase of 10,000 residents and 5,000 new dwellings per year. In this context, Buiksloterham entered the strategic focus of the municipality as a potential area for housing provision and brownfield redevelopment (Metabolic, Studioninedots & DELVA Landscape Architects, 2014).

In November 2002, Amsterdam Noord presented a draft Masterplan for the development of the district. The document outlined the redevelopment of the northern bank of the IJ river as a mixed-use area that would combine industrial functions, workspaces, residential uses, recreational areas, and additional urban facilities. In 2006, the municipality approved the investment plan for the redevelopment of Buiksloterham. In 2009, the planning process was concluded through the adoption of a revised zoning plan for the district. The approach adopted by



2. Buiksloterham neighbourhood aerial view. Base map from Google

the municipality at that time was unconventional. The severe level of soil contamination made it economically unfeasible for the local authority to acquire the land and remediate it prior to redevelopment. As a result, a gradual transformation process was promoted through a step-by-step strategy. This process relied on a flexible masterplan and on a set of performance-based "rules of the game" designed to guide development. These rules enabled experimentation and supported the pursuit of circular urban development, thereby acting as a catalyst for transformation. The global financial crisis subsequently slowed down development plans across the city. As a consequence, the area remained characterised by a limited provision of public spaces, green areas, and facilities, as well as by numerous vacant brownfields that were often heavily polluted and therefore inaccessible (ibid.).

Within this context, the municipality introduced a series of incentives aimed at revitalising interest in the area and improving its environmental sustainability. These measures included the allocation of plots for self-building initiatives and the temporary concession of specific areas to support the establishment of creative activities. As a result of these incentives, the first housing development was completed in 2013. In 2014, Buiksloterham was designated as a key innovation area for circular urban development in Amsterdam during an event focused on water-related innovation. This recognition led to the formulation of a more comprehensive sustainability strategy and long-term vision. The strategy was formally articulated in 2015 through the publication of the "Manifest Circular Buiksloterham". This document was also signed by the Municipality of Amsterdam and defined a shared vision for the development of the site up to 2034 (ibid.).

The circular district was defined by its planners as a resilient city capable of continuously reinventing itself. It was described as a healthy urban environment that optimally uses material flows while maintaining and strengthening the diversity of nature and culture (DELVA Landscape Architects et al., 2016). Six core principles were identified to guide the development of Circular Buiksloterham, with effective resource management recognised as a central element. These principles aim to achieve both efficient closed material flows and the creation of flexi-

ble, healthy, and adaptive communities. Within this vision, materials are used, reused, and recycled in order to eliminate the concept of waste. The local availability of materials determines the spatial scale at which material cycles can be closed, as more widely available materials enable smaller and more localised cycles. Energy production is based exclusively on renewable sources, while biodiversity is protected and restored. Cultural diversity is preserved, as it contributes to the resilience of the overall system. The health of both humans and other species is actively supported, and the use of toxic materials is avoided. The overarching objective of human activity is the creation of added value, given the scarcity of natural resources and the need to use them only for this ultimate purpose. Flexibility and adaptability are treated as fundamental qualities. These qualities relate to the capacity of the city to evolve in response to changing circumstances, with both infrastructure and institutions required to pursue these values (ibid.).

A number of projects were selected to implement the envisioned circular city within the district, and many of them place sustainability at the core of their objectives. Among these initiatives, De Ceuvel represents a particularly significant case study due to its role in positioning Buiksloterham as a destination of interest for both residents and visitors. De Ceuvel originated from the idea of temporarily reusing the Ceuvel Volharding site, a former shipyard in Buiksloterham that had remained unused and had effectively become an urban brownfield. The project can be interpreted as an example of adaptive reuse that combines environmental sustainability with cultural and creative initiatives. The approach followed a top-down logic, as the municipality approved only those proposals that explicitly promoted creativity and environmental sustainability. This orientation is consistent with the Dutch tradition of adaptive reuse, which is supported by dedicated policies and is widely recognised as an effective tool for urban regeneration, the reinforcement of local identity, and the resolution of vacancy issues (Mérai et al., 2022).

The tender for the site was awarded in 2012 to the Amsterdam-based architecture firm Space&Matter and to architect Marjolein Smeele of the Smeelearchitecture agency. The land was secured through a ten-year lease agreement. De Ceuvel con-

sists of a large area composed of seventeen former houseboats that were transformed into buildings hosting innovative businesses. The site currently accommodates twenty-six companies and a floating hotel, while three additional boats remain available for rent for events, meetings, and workshops (Metabolic, 2023). A café is also located within the area. It was designed using upcycled materials and offers locally sourced organic food.

Beyond its cultural and economic functions, De Ceuvel primarily operates as a site for phytoremediation, where specific plant species are cultivated to clean the polluted soil. Resource management is organised according to circular principles and relies on low-cost technologies. Plants are used to extract pollutants from the soil while simultaneously contributing to the creation of a green and accessible environment surrounding the renovated houseboats. In addition to phytoremediation, a smart grid system has been implemented to manage and share electricity. The system operates through a local currency known as Jouliette. Jouliettes are generated when users produce surplus solar energy, and the use of this currency makes local energy sharing more advantageous than selling excess electricity back to the main grid (De Ceuvel, 2023). A decentralised wastewater treatment system has also been installed.

At the initial stages of the transformation, several regulatory constraints emerged. Some buildings lacked a connection to the conventional sewage system, which conflicted with existing municipal regulations. Through cooperation with the municipality, specific exemptions were granted in order to allow experimentation and to evaluate the innovative outcomes of the project. As a result, De Ceuvel became an internationally recognised circular economy case study (Metabolic, 2023). The city council formally designated the area as a "Living Lab," thereby enabling the application of flexible regulatory conditions. Consequently, the City Lab Buiksloterham was institutionalised as a community foundation (Ersoy & van Bueren, 2020).

From a management perspective, De Ceuvel was developed and is currently managed by the non-profit tenants' association known as the "Association de Ceuvel". The association is responsible for the management of the studio boats. Three boats are open to the public: the Crossboat, the Metabolic Lab, and the Workship. The Workship functions as a multifunction-

al space for studios, rehearsals, and workshops. The Metabolic Lab serves as a dedicated space for education and knowledge exchange on sustainability-related topics. Unlike the original houseboats, the Metabolic Lab and the Crossboat were constructed using financial resources provided by the association. The Crossboat was designed to reach a broader audience and hosts workshops, training sessions, and public lectures. The members of the association and the tenants form the core community of De Ceuvel. Bottom-up initiatives play a crucial role in the functioning of the site. Activities such as volunteer days, during which groups of fifty to one hundred people actively contribute to site maintenance and management, have been essential to the success of the project and to the strengthening of community bonds.

Despite attracting visitors, students, and media attention from across the world, the future of De Ceuvel remains uncertain. The temporary lease agreement is scheduled to expire at the end of 2026, although additional years were granted by the municipality after the project was initially expected to conclude on 1 January 2024. Over time, De Ceuvel has evolved into a permanent space for experimentation, and the investors have expressed interest in maintaining the project beyond its temporary status. In this regard, the impermanence of planning permissions can also be interpreted as a barrier, as it limits opportunities for scaling up initiatives (Williams, 2021). According to the terms of the agreement, the site must be returned to the Municipality of Amsterdam in a condition comparable to that in which it was received, albeit with improved environmental quality. At the same time, temporality represents a defining and innovative characteristic of the project. The circular, flexible, and movable design of De Ceuvel offers potential for transferability to other docklands, given that the project is largely composed of houseboats without permanent foundations or sewage connections. The primary challenge lies in adapting this experimental model to other local contexts, which inevitably differ in their social, cultural, economic, and environmental conditions.

Key take-away messages

The first key message emerging from the analysis of Amsterdam is that temporary planning permissions and designated experi-

mentation zones function as effective instruments for overcoming regulatory and political barriers. These tools support a shift towards a performance-based planning approach. In line with the vision articulated by the architects of De Ceuvel, the resilient circular city is not something that can be fully designed in advance but rather a process that should be allowed to emerge over time (DELVA Landscape Architects et al., 2016).

This perspective highlights two main aspects. The first concerns the need to move beyond the prescriptive approach that characterises rigid planning instruments such as masterplans. The development of De Ceuvel required a change in zoning regulations and the navigation of a complex building permit procedure to accommodate an unconventional project. As the integration of circular economy principles into local planning instruments has become increasingly necessary, existing urban planning tools require substantial adaptation. Effective transformations are occurring primarily at the local scale, where planning instruments must therefore evolve accordingly.

The second aspect relates to the opportunity to enable experimentation within specific urban areas in order to test innovative solutions. Such solutions would otherwise encounter significant regulatory obstacles under standard planning procedures. In the case of De Ceuvel, several technical issues would have prevented implementation under conventional regulatory frameworks. Many challenges, including conflicts between land-use functions and environmental standards, were overcome through the formal recognition of Buiksloterham as a Living Lab by the municipality. In this context, the establishment of an experimental zone in which the underlying rationale of regulations is prioritised over their strict application created a pathway for fostering innovation and advancing circularity in Amsterdam.

At the same time, the case study reveals that the adaptation of the Living Lab model to a broader urban scale remains challenging. This limitation is compounded by the absence of a dedicated institutional framework to support such scaling processes (Ersoy & van Bueren, 2020). The scalability of experimental solutions may be constrained by their limited suitability at larger spatial scales, as well as by insufficient support and engagement from local communities and future residents.

A second key dimension that emerges from the analysis concerns the role of culture and social inclusion as drivers of sustainability. Cultural activities and creative practices facilitated bottom-up initiatives and supported the dissemination of sustainability values. De Ceuvel originated through a top-down initiative promoted by the municipality, which sought to combine environmental sustainability objectives with the development of creative solutions. Within this context, culture has been employed as a tool for communicating environmental sustainability messages. This approach has been implemented through the organisation of cultural events and activities designed to engage tourists, children, and residents of nearby neighbourhoods (Mérai et al., 2022).

However, in relation to social participation and citizen engagement, significant limitations can be observed at De Ceuvel. The empowerment of diverse social groups remains limited, and neither intragenerational equity nor equitable access to cultural facilities for disadvantaged groups is actively pursued. Local residents tend not to frequent De Ceuvel, largely due to the high prices of the café and the nature of the activities offered (ibid.). From this perspective, De Ceuvel cannot be fully regarded as an example of culturally sustainable development. The role of culture has primarily been instrumental in achieving environmental and financial objectives rather than fostering inclusive social outcomes (ibid.).

Greater emphasis on bottom-up initiatives and co-design experiments could contribute to the development of more inclusive projects. In addition, the incorporation of explicit social and cultural sustainability criteria within public tenders, together with systematic assessment of these criteria in project outcomes, could support the design of urban development processes that are more socially inclusive.

2.2. Prato: the Italian leader in the Urban Agenda partnership for circular economy

Prato is an Italian municipality located in Tuscany and represents the second most populous city in the region. The city is internationally known for its textile industry, which accounts

for approximately 3 per cent of European textile production (Circular Cities Declaration, 2022). Prato's pathway towards circularity began in 2016, when the city represented Italy within the Urban Agenda Partnership on Circular Economy. The municipality further strengthened its commitment by signing the Circular Cities Declaration in 2020.

The model proposed by the City of Prato is based on the adaptation of European experiences at both the city and district scales. This model is structured around three main axes: innovation in production processes, urban regeneration, and the strengthening of social cohesion.

Building on the experience gained through the European partnership, the City of Prato proposed a series of concrete actions aimed at overcoming key barriers to circular transitions. These actions focus on improving regulation, funding, and knowledge. The regulatory dimension seeks to promote changes within the existing normative framework by fostering cross-sectoral and multi-level collaboration. This approach is particularly relevant given the structure of Italian governance, which is characterised by the interaction between regions and municipalities. Since cities lack legislative competences at the supralocal level, the establishment of strong links with regional, national, and European institutions is essential. Improved legislation can facilitate the recovery and reuse of waste and by-products, as well as enable temporary or permanent changes in land-use designations.

The funding dimension focuses on identifying both traditional and innovative financial opportunities. These include European Structural and Investment Funds and the development of strong partnerships at the city and district levels. Improved access to funding can support the adoption of less environmentally impactful technologies and facilitate changes in the use and adaptation of buildings. The knowledge dimension aims to promote awareness-raising actions across all levels of society. The objective is to foster a sense of belonging to the systemic mechanism represented by the circular city. Enhanced knowledge can influence companies and citizens towards more informed consumption patterns. It can also encourage citizens to reclaim underused or unused buildings and spaces, thereby strengthening participation and co-design processes and increasing the positive impacts of interventions on health and wellbeing.

Historically, practices of recovery, reuse, and recycling have been central to innovation within Prato's textile sector. These practices were developed to reduce waste sent to landfills and to replace primary raw materials with secondary resources. In Prato, the circular economy also encompasses the construction of a centralised industrial water treatment plant. This infrastructure represents an alternative water supply system designed to ensure the reuse of water within textile production processes. In addition, circular economy principles are applied to the reuse and regeneration of existing built heritage, particularly industrial buildings. Several key institutions in Prato are currently located within regenerated industrial structures.

Alongside the numerous virtuous initiatives developed at the micro scale, the municipality has emphasised the importance of promoting circular models that pursue sustainability through an integrated and systemic perspective. Prato Circular City represents the integrated strategy promoted by the Municipality of Prato to support the city's transition towards the circular economy. The homogeneous production district that characterises the Prato area presents particularly favourable conditions for fostering circular transitions, innovation, and sustainability. Following the global health emergency linked to the Covid-19 pandemic, the municipality has also identified the need to reconsider lifestyles, training systems, spatial practices, and production processes in a more sustainable direction.

Prato Circular City pursues several core objectives. These objectives include promoting the city's transition towards the circular economy, strengthening Prato's image as a circular city, creating a permanent environment for dialogue among local stakeholders to support shared, integrated, and participatory circular economy actions, and establishing a governance framework for the circular city.

Prato Circular City has been implemented as a living lab designed to foster cohesion, participation, and impact in the city's circular transition. The living lab operates through a structured process. The first phase involves the identification of relevant stakeholders based on thematic relevance and willingness to participate. The second phase focuses on the organisation of thematic working tables within the identified areas and for specific topics. The third phase concentrates on selected top-

ics that are chosen and validated by participants and discussed within dedicated working groups. The fourth phase involves the presentation of proposed actions to a wider audience beyond the working groups and the collection of feedback. In line with the strategic axes of the European Partnership, participants are required to identify and share initiatives, good practices, and existing networks related to knowledge, relevant legislative frameworks related to regulation, and appropriate funding opportunities. This process ensures that only relevant and feasible ideas proceed to the definition of concrete actions.

Working groups within Prato Circular City operate through three different formats. Operational Working Groups formulate hypotheses to overcome at least one identified barrier, based on the existing state of the art and on initiatives already implemented at local and supralocal levels. Cross-cutting Working Groups consist of groups that were already active prior to the launch of Prato Circular City. These groups use the Prato Circular City platform to operate in an integrated manner on their specific topics while explicitly incorporating circular economy principles into their discussions. In addition, an observatory has been established as a forum for discussion and in-depth analysis of economic and social dynamics.

Prato Circular City was officially launched in 2020 and became a forum that engaged local stakeholders in the co-creation and implementation of circular economy actions. The initiative effectively functions as the governance mechanism for the strategy (Borsacchi, Tacconi & Pinelli, 2021). Between September 2020 and February 2021, fourteen working group meetings were organised, leading to the identification of five actions to be implemented in the subsequent phase. Overall, the living lab enabled the involvement of qualified stakeholders, and local administrators demonstrated openness to listening to their needs. However, during the initial phase of implementation, a limited level of citizen involvement was observed (ibid.).

Prato Circular City has also enabled the extension of discussions to other programmes and strategies pursued by the municipality. As a result of the work carried out within the Prato Circular City working groups, a comprehensive strategic document entitled “Next Generation Prato” was approved in 2021. The circular transition is fully integrated into this document

and permeates the majority of the projects proposed by the municipality.

Finally, the activities developed within the European partnership and the cross-disciplinary debate surrounding the vision of Prato Circular City have influenced urban planning instruments and strategies. Both the new municipal structural plan approved in 2024 and the operative plan are informed by and permeated with circular economy principles.

Key take-away message

The main lesson emerging from this Italian case study concerns Prato's participation in the European Union Partnership on circular economy. This experience enabled the city to develop in-depth knowledge of circular economy principles and to articulate a clear and coherent vision for its circular transition. It also represents an example of the adaptation of European policies and practices to the local scale.

Prato Circular City constitutes a top-down strategy that has successfully permeated multiple sectors of public administration. The strategy has encouraged cross-cutting debate among a wide range of stakeholders, including representatives of the local economy and policymakers. Several working groups have yet to be activated, and for this reason the potential of Prato as a living lab for testing circular initiatives remains at an early stage of development. At the same time, some projects have already moved into the implementation phase.

A further strength of this experience lies in the establishment of a dedicated section on the official website of the Municipality. This digital platform collects all initiatives related to the circular strategy of the territory and helps to avoid fragmentation and duplication. It also contributes to conveying the image of Prato as a circular city in a coherent and unified manner.

2.3. Concluding remarks: contrasting pathways towards circular urban transition

The comparative analysis of Amsterdam and Prato highlights how circular urban transitions can follow different yet complementary pathways, shaped by local governance structures, in-

stitutional capacities, and strategic priorities. While both cities explicitly adopt the circular economy as a guiding framework for urban transformation, their approaches diverge in terms of implementation logics, scale of intervention, and modes of policy integration.

Amsterdam represents an advanced and experimentation-driven model of circular transition. The city prioritises flexibility, temporary regulatory arrangements, and performance-based approaches to enable innovation in contexts characterised by uncertainty and complexity. Experimental zones and living labs, such as Buiksloterham, function as testing grounds for alternative socio-technical configurations and circular practices that challenge conventional planning tools. At the same time, the Amsterdam case reveals structural limitations related to scalability and long-term institutionalisation, as experimental solutions often remain confined to specific areas and rely on exceptional regulatory conditions.

Prato, by contrast, exemplifies a governance-oriented and strategic approach to circular transition. Prato Circular City operates as an integrated municipal framework that coordinates policies, stakeholders, and planning instruments around a shared vision of circularity. The experience gained through participation in the European Union Partnership on circular economy has played a crucial role in shaping this approach, enabling the localisation of European policies and fostering cross-sectoral collaboration. Although the implementation of concrete circular initiatives is still at an early stage, Prato demonstrates a strong capacity to embed circular economy principles within formal planning documents and institutional processes.

From a comparative perspective, the two cases reveal a tension between experimentation and institutional consolidation. Amsterdam excels in generating innovative practices and testing new models through spatial experimentation, but struggles to translate these experiences into systemic and city-wide transformations. Prato shows the opposite dynamic, with a strong emphasis on strategic coherence and governance integration, but a more limited capacity for place-based experimentation and rapid implementation.

The analysis suggests that effective circular urban transitions require a balance between these two dimensions. Experi-

mental approaches are essential to explore innovative solutions and challenge existing regulatory frameworks, while strategic and institutional embedding is necessary to ensure continuity, scalability, and long-term impact. In this sense, Amsterdam and Prato should not be interpreted as competing models, but rather as complementary pathways that together illustrate the multi-dimensional nature of circular urban transformation.

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3. CIRCULAR CITIES IN URBAN PLANNING: TOWARDS A HOLISTIC CIRCULAR THINKING

3.1. The role of urban planning in fostering circular urban development

European initiatives, such as the Circular Cities and Regions Initiative, tend to emphasize the development of circular economy businesses within cities rather than supporting a comprehensive and holistic transition. This focus is reflected in the current application of the circular economy concept at the urban scale, where so-called circular cities are often understood as the aggregate of circular activities established within the city, primarily evaluated through financial indicators (Marjanović et al., 2022). Consequently, the implementation of policies in practice remains fragmented and reveals the absence of a comprehensive framework for interpreting the circular economy concept that can effectively assist policymakers in planning more circular urban areas (Marjanović et al., 2022; Millar et al., 2019; Moreau et al., 2017; Sánchez Levoso et al., 2020). Moreover, Papageorgiou et al. (2021) argue that no holistic pathway currently exists to measure the progress, impact, and opportunities of circular economy strategies applied in cities.

Policy analysis confirms that the circular economy is predominantly regarded as a solution for achieving efficient waste management and resource use, a perspective largely driven by European waste policies and directives developed since the 2000s. This interpretation is often referred to as the "Old Circular Economy" (Zoboli et al., 2019). To adopt a "New Circular Economy," the approach to circularity must be expanded to address challenges beyond the mere closure of material flows and waste management (ibid.).

Spatial planning is generally regulated at the national or regional level depending on the governance structure of Member States, and thus its potential role in facilitating the transition

to a circular economy is seldom acknowledged in international and European policy frameworks. Within the Italian context, urban areas and their governance are notably addressed in the National Circular Economy Strategy (SNEC), although the explicit recognition of spatial planning's role remains limited. The SNEC highlights the need to rethink cities and territories from a circular perspective, advocating for an intersectoral and systemic approach. From an urban planning standpoint, relevant indicators linked to the SNEC's objectives primarily concern soil management (e.g., reuse of abandoned sites; reduction in square meters of nationally significant polluted sites) and water management (e.g., wastewater treatment), while other indicators focus mainly on waste management and innovation in new economic activities.

Urban planning has the capacity to designate spaces within cities for circular functions such as urban agriculture, storage and logistics facilities, waste management, and green areas, while also enabling temporary uses like pop-up activities (Williams, 2020, 2023). This is exemplified by the Emilia-Romagna region's implementation of Regional Law 24/2017. Importantly, soil represents a critical urban resource, and spatial planning plays a decisive role in its management, thereby significantly influencing circular urban development (ibid.). Promoting flexible zoning regulations is essential to support multifunctionality and adaptability (Fusco Girard & Nocca, 2019).

Moreover, spatial planning can facilitate the expansion of green spaces within urban environments. By encouraging the adoption of nature-based solutions, ecosystem services can generate benefits for both the biosphere and urban areas, consistent with the objectives of the New Urban Agenda. Closing the resource loop enhances efficiency in resource and energy use and reduces pollution emissions. Simultaneously, increasing sustainability potential through climate change adaptation is vital, and nature-based solutions contribute significantly to this aim (ibid.).

However, the integration of the circular economy concept into urban planning at the city scale remains underdeveloped and requires further investigation to clarify how this integration can be effectively operationalized within planning tools and practices.

3.2. Existing knowledge on circular economy in urban planning

Based on a systematic literature review of scientific articles, book chapters, and conference proceedings published between October 2022 and May 2023, the planning dimension of urban circularity has been critically investigated. A total of 195 publications were initially analysed through bibliometric methods, and 119 medium-to-high relevance contributions were subsequently examined through full-text analysis (Marzani & Tondelli, 2024). While the bibliometric review served to identify the main themes associated with the circular city concept from a planning perspective, the in-depth qualitative assessment enabled a more nuanced understanding of how circular economy principles are currently interpreted and operationalised within urban planning research.

The literature largely addresses circularity through sector-specific lenses, with particular emphasis on material flows, the built environment, and natural capital. Regarding natural capital, significant attention is devoted to nature-based solutions, reflecting their central role in circular economy principles and urban regeneration. Research highlights the contribution of nature-based solutions to resource recovery, water management, and ecosystem restoration, and identifies key urban circularity challenges that nature-based solutions can address, including water and waste treatment, nutrient and material recovery, energy efficiency, and building system regeneration.

The built environment emerges as a dominant focus, given its high levels of resource consumption and environmental impact. Studies underline the relevance of transitioning towards a circular built environment through concepts such as urban mining and life-cycle assessment, which support evidence-based policymaking. However, despite the inclusion of the built environment in several circular city frameworks, the literature reveals a limited discussion on policy instruments, implementation mechanisms, and their integration with statutory urban planning tools. Adaptive reuse of cultural heritage buildings is consistently framed as a coherent strategy within holistic circular city approaches, reinforcing the relevance of regeneration, reuse, and long-term adaptability.

Resource flows and waste management constitute another major research strand, often addressed through urban metabolism frameworks. While these approaches provide valuable insights into the composition of urban resource flows, fewer studies engage with their spatial distribution and governance implications. Mobility and transport systems, despite their relevance to urban metabolism, remain marginally addressed. Similarly, although digital technologies and ICT are widely recognised as potential enablers of the circular transition, their role in urban planning and circular economy-related policymaking is still underexplored.

Monitoring and evaluation frameworks represent a prominent theme in the literature, with numerous indicator-based approaches proposed to operationalise the circular city concept. While some frameworks adopt holistic perspectives, many focus on specific circular economy dimensions—such as waste management, social aspects, industrial symbiosis, or heritage reuse—highlighting a fragmented research landscape. The absence of a consolidated and widely accepted indicator system reflects both the complexity of urban circularity and the lack of a shared definition of the circular city. From an urban planning perspective, scholars stress the need to identify a limited yet meaningful set of indicators that can be effectively applied by public administrations and allow comparability across cities while respecting territorial specificities.

Since 2019, increasing attention has been given to decision-making processes supporting circular city development, including policy recommendations and multi-criteria decision-support tools. These approaches acknowledge the necessity of interdisciplinary perspectives and seek to balance environmental, social, economic, and cultural dimensions. Nevertheless, empirical applications remain limited.

Stakeholder engagement and participatory processes are increasingly recognised as critical enablers of circular transitions. Methods such as living labs, geodesign environments, interviews, and collaborative spaces aim to foster shared visions and co-production among citizens, policymakers, and other stakeholders. Despite this growing interest, research in this area is still at an early stage, and stronger efforts are needed to promote cross-sectoral collaboration, institutional integration, and

meaningful citizen participation, combining bottom-up and top-down approaches.

Spatial scale emerges as a crucial issue in the application of circular economy principles. The literature discusses circularity across multiple scales—from regional and peri-urban to district and municipal levels—each involving different actors, competences, and planning instruments. Regional and landscape-based approaches are identified as particularly suitable for managing resource and waste flows, while local-scale initiatives enable experimentation and contextual adaptation. Scholars highlight the need to integrate physical transformations with the circular functioning of socio-economic systems, stressing the planner's role in aligning land use, regeneration practices, and governance mechanisms with circular ambitions.

Overall, the literature confirms a persistent gap between circular economy theory and urban planning practice. Although several conceptual and methodological contributions call for stronger integration, a consolidated operational framework is still lacking. Social dimensions remain comparatively underrepresented, although recent studies increasingly acknowledge their importance for fostering behavioural change, inclusivity, and adaptive capacity. Regeneration practices and adaptive reuse are identified as promising entry points for embedding circularity into urban development, yet they remain insufficiently explored. Collectively, these findings underline the need for more integrated, spatially explicit, and socially grounded approaches to advance the circular city agenda within urban planning.

3.3. Existing theoretical frameworks to interpret circularity in urban planning

Scholars widely acknowledge the necessity of adopting holistic approaches to enable circular transitions (Millar et al., 2019; Moreau et al., 2017); however, the pathways through which comprehensive and integrated circular transformations can be effectively achieved remain insufficiently defined (Marjanović et al., 2022). In this context, frameworks that support spatial planning can be understood as structured sets of principles,

guidelines, indicators, and operational tools designed to assist municipalities in embedding cross-cutting concepts—such as circularity—into local governance and planning processes (Vogel et al., 2019). Within such frameworks, principles articulate a long-term vision that enables decision-makers to conceptualise a "circular" urban state, while objectives and guidelines facilitate the transition towards this vision. Indicators and tools, in turn, provide mechanisms to assess both baseline conditions and progress over time. To be effective, these frameworks must integrate environmental and socio-economic dimensions and remain sensitive to local characteristics and political contexts (Keiner & Schmid, 2006; Vogel et al., 2019).

Nevertheless, the proliferation of theoretical frameworks that lack practical applicability represents a significant risk. In response to this challenge, and in an effort to overcome fragmented and sector-specific approaches, recent analyses increasingly emphasize the need for integrated and multidimensional perspectives on circularity. Consistent with Marjanović et al. (2022), a holistic approach is understood as one that addresses the full spectrum of urban sectors, services, activities, and lifestyles, while simultaneously promoting methodological integration across spatial scales and policy domains.

Within this line of reasoning, Williams' conceptualization of circular urban development provides a particularly coherent and comprehensive contribution. Her framework is grounded in looping, regenerative, and adaptive actions, and explicitly bridges circular economy principles with urban planning theory and practice (Williams, 2020, 2023). This holistic perspective is further substantiated through comparative analyses of circular initiatives in major European cities—including London, Paris, Stockholm, and Amsterdam—demonstrating how circular development principles can be operationalized across diverse urban contexts (Williams, 2021a).

Williams (2021a) proposes an action-based framework to interpret circular urban development. Her book titled *Circular cities: A revolution in urban sustainability* presents a framework based on the conceptualization of the city as a socio-ecological complex system and acknowledges the important role of social actors and stakeholders, thus adopting the holistic approach as defined in the premise of the paragraph. Another strength

is that it is strongly action-based: the author started her work with an examination of the ReSOLVE framework[1], highlighting its limitations when applied to the city scale, then proposing a way of overcoming the barriers and taking advantage of the opportunity that a city might have. Finally, Williams presents three actions that are considered fundamental to achieve a circular urban transition:

- **Looping actions:** they are exemplified mainly as reuse, recycling and energy recovery actions, aiming at closing the current linear flows, reducing waste and increasing energy efficiency. Waste-heat recovery, food reuse, bio-refineries, grey water recycling, adaptive reuse of buildings are examples of the looping actions.
- **Ecologically regenerative actions:** they are actions aiming at regenerating urban ecosystems thus providing ecosystem services and are exemplified by the adoption of green and blue infrastructure into the urban realm and the conservation of existing urban ecosystems.
- **Adaptive actions:** they are aiming at building capacity both within the urban fabric and the communities in order to adapt to change. Examples include the use of flexible design, temporary urbanism, collaborative planning, co-provision and system for learning.

In addition to these three fundamental actions, four additional categories are introduced to complement the framework and encompass the strategies that different urban contexts may adopt in tailoring the framework to their peculiarities in terms of social, cultural, economic, political and technological background. These strategies are optimization, substitution, localisation and sharing. Among the optimization actions the introduction of smart grid, energy efficiency in buildings and community heating systems are mentioned. Examples of substitution are the transition from fossil finite resources to renewable ones, resource-based activities with service-based activities, teleworking. Sharing practices involve co-housing, library of things, co-working and the use of public transport or vehicle-sharing options. Localisation of resource flows and activities at city and regional level, can encourage synergies and reduce negative externalities if considering both the production and the demand side.

The framework is based on the three principles that are echoing the Ellen MacArthur Foundation's ones:

- Reduce resource consumption and waste.
- Preserve and expand natural capital and ecosystem services.
- Design out negative externalities associated with wastage of resources and natural capital degradation. (Williams, 2019a).

Williams' work depicts a clear and holistic approach towards circular urban development that is addressed also from the urban planning perspective (Williams, 2020, 2023) and through the analysis of four cities' actions: London, Paris, Stockholm and Amsterdam (Williams, 2021a). Benefits and challenges to circular urban development have been assessed too (Williams, 2019b, 2021b, 2022). The SWOT analysis of this framework is reported in the table below.

Tab. 2. Williams' action-based approach to circular city. A SWOT analysis concerning its implementation into policy-making

Strengths	**Weaknesses**
Cities are considered in their complexity, as socio-ecological systems. The framework is action-oriented. There is an analysis of challenges and benefits for the effective implementation of the actions. Case-studies are analysed in support of the knowledge-transfer into practice.	The framework is action-oriented and it is difficult to envision how components of a circular urban ecosystem will look like, being a barrier for its implementation. The distinction between core and supportive actions is articulated and may be difficult to be endorsed in policy-making.
Opportunities	**Threats**
The actions may support the definition of a concrete image of the circular city. The framework can be used in support of policy-making. The four additional categories of actions allow different cities to interpret circularity according to their peculiarities.	The actions belonging to different categories may be in contrast between each other.

The Circular City Actions Framework (ICLEI – Local Governments for Sustainability et al., 2021) has been developed by ICLEI, Circle Economy, Metabolic and the Ellen MacArthur Foundation and it is available online. It aims to inform cities about the range of strategies and actions available in order to start the transition towards circular development at the local

level. It is also built on the three circular economy principles developed by the Ellen MacArthur Foundation (Ellen MacArthur Foundation, 2015), the 9Rs Framework (Potting et al., 2017) and Circle Economy's Key Elements Framework[2] and adapts them to fit the specific context of cities and sharpen the focus on stimulating systemic change. Five complementary strategies are proposed by the framework:

- **Rethink:** redesign the system by laying the foundation for circular activities and enabling the transition towards CE. The outcomes of this first strategy are adaptive urban systems, self-sufficiency is supported, residents are reconnected to the value chain, inclusiveness is fostered, consumption-based emissions are addressed, all citizens have equitable access to goods and services.
- **Regenerate:** harmonize with nature and embrace infrastructure and production systems that allow natural ecosystems to thrive. Among the expected outcomes there are production and consumption practices that do not exceed the carrying capacity of the natural systems, regenerated ecosystems and biodiversity, urban systems better equipped to adapt to climate change impacts, solutions inspired and supported by nature, renewable resources are prioritized.
- **Reduce:** do better with less by designing infrastructure and products to minimize material, water, energy use and waste generation. The foreseen outcomes related to this strategy are the elimination of toxic materials, the reduction of the overconsumption of resources, the reduction of the material input, total extraction, waste and greenhouse gas emissions, reduced health impact due to pollution as well as the reliance on scarce resources.
- **Reuse:** the principle is highlighting the aspect of a longer and more frequent use of existing resources, products, spaces and infrastructure, thus extending and intensifying their use. Among the outcomes, consumption-based emissions are addressed, total waste is reduced as well as the energy needs, local employment is supported, second-hand markets, sharing and exchange platform are eased, the reuse, repair and remanufacturing and maintenance is supported.

- **Recover:** maximize the recovery of resources and reintroduce them into the production process at the end of the usage phase. It means to reduce the total extraction, the material and energy input and waste, support employment opportunities, local economy and innovation.

According to these specific characteristics, the framework is quite holistic, action-oriented and relevant, especially because it explicitly targets local governments. The SWOT analysis is reported below.

Tab. 3. ICLEI's circular city actions framework. A SWOT analysis concerning its implementation into policy-making

Strength	**Weaknesses**
It is based on 5 strategies and 15 linked actions, easy to understand by policy-makers. Case-studies are reported, consisting of good practices from which local governments can take inspiration from. The target group of the framework are explicitly the local governments.	Many outcomes overlap between the different actions and it can possibly generate confusion in policy-makers. Specific targets for the actions are missing. It focuses on actions without connecting them to specific urban ecosystems.
Opportunity	**Threats**
Good practices can be potentially replicated by other local governments, paving the way for a virtuous pathway.	Synergies with other already existing sustainability strategies are not highlighted. Conditions and/or barriers to replicate good practices are not provided. Replication of good practices may hinder the development of holistic strategies at city level, and reduce the circular city concepts as a sum of CE activities within the city.

3.4. Towards holistic circular thinking: discussion on the reviewed frameworks

As mentioned in premises of the previous paragraph, one of the biggest risks is to propose too many theoretical frameworks that are not attainable in practice, although there is the need to pass from strategies to actions. The study of different cases is also recurrent among the frameworks even though with different approaches; according to Williams, the four case studies help in understanding the complexity and the possibility of different local contexts to interpret circularity, while ICLEI's model is

based on actions that cities are undertaking appearing more like a collection of existing good practices that inspired the methodology and from which cities can, in turn, be inspired. As far as the urban domains are concerned, the top-down conceptualization of the circular cities is referring to the interpretation of the city as complex socio-ecological-technical systems. In table 4 a summary of the different features of the two frameworks is provided, comparing them according to their ability to inspire a vision for the circular transition, the urban target considered, the availability of a guidance for the transition and lastly, the presence of indicators or tools to holistically support the transition.

As far as the author knows, none of these frameworks has been implemented by cities to build and design the transition towards circularity.

Tab. 4. Discussion of the reviewed framework for circular cities

Framework	Principles inspiring the vision of a circular city	Urban targets considered	Guidelines for the transition	Indicators and tools
Williams	+ Clear strategic actions to achieve a circular urban development	+/- Cities as complex socio-ecological systems	+ Clear strategic actions to achieve a circular urban development	- Partially developed framework for a seaport
ICLEI	+ Clear R-strategies to achieve circularity in cities	- Not specified in the framework	+ Clear actions to achieve circularity in cities	- No indicators are proposed

The two models are clearly providing principles inspiring a vision of the circular city. Both Williams' socio-ecological conceptualization and ICLEI's R-strategies diagram are interpreted by highlighting the spatial planning perspective of the proposed principles, in the following tables 5 and 6.

Tab. 5. Williams' Framework analysed through the spatial planning perspective

Williams, J (2021)	Explanation	Spatial planning perspective
Looping	Reuse, recycling and energy recovery.	Building refurbishment to increase the quality of urban and public spaces. Provision of closed-loop infrastructural systems like recycling ones. Identification of positive-energy districts. Inclusion of circular criteria into the green public procurement (recycled materials for intervening on buildings). Water and grey-water cycle management. Waste-to-energy management.
Regenerate	Regeneration of urban ecosystem and ecosystem services.	Protection and restoration of natural capital. Green and blue infrastructure network identification and protection. Incentives for nature-based solutions in urban areas. Integration of ecosystems services into urban planning tools.
Adapt	Communities able to adapt to change; collaborative planning; co-design practices; flexible design and temporary planning; raising awareness.	Collaborative planning. Co-design for climate change adaptation. Temporary experimentation with citizens involvement (e.g. Amsterdam case study). Flexibility in planning towards temporary uses. Flexible infrastructure that evolves with changing needs (e.g. scalable, movable, adaptable to new purposes).

Tab. 6. ICLEI's framework analysed through the spatial planning perspective

ICLEI	Explanation	Spatial planning perspective
Rethink	Adaptive urban systems that are self-sufficient, inclusiveness; equitable access to goods and services for all citizens.	Incentives for circularity transition of the built environment fostering density, mixed-uses and high accessibility with public transport. Identification of cross-sectorial synergies to plan closed-metabolism districts. Enable sustainable lifestyles through the identification of spaces for circular activities. Planning for multi-use spaces in strategic areas of the city.
Regenerate	Harmonize with nature and embrace production systems that allow natural ecosystem to thrive; urban areas equipped to adapt to climate change impacts.	Protection and restoration of natural systems. Promotion of nature-based solutions in urban areas. Promotion of the transition to renewable energy.
Reduce	Minimise material, water, energy use and waste generation; reduce material input and total emissions.	Green public procurement with circular criteria for buildings and material use. Water and energy saving infrastructure and conservation.

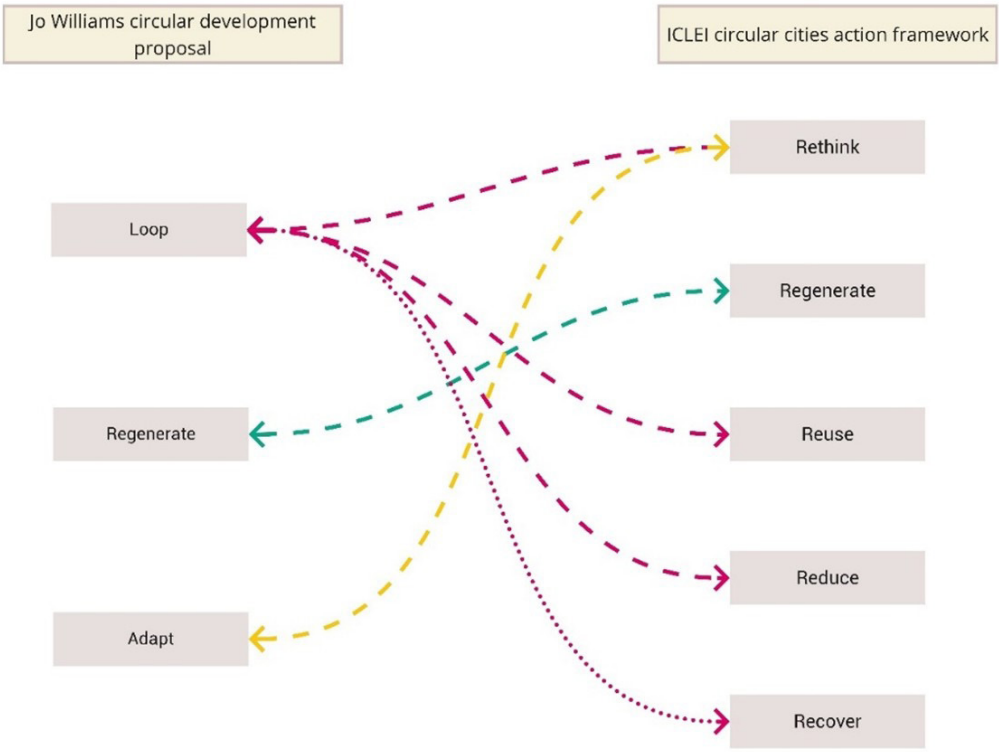
Reuse	longer and more frequent use of existing resources, products, spaces and infrastructure, thus extending and intensifying their use.	Identification of spaces for the reuse of objects and infrastructure. Extend and optimize the use of spaces. Incentives for second-hand markets and maintenance of existing spaces and infrastructures. Support for car, bikes and scooter sharing and increase of accessibility to public transport.
Recover	Maximise the recovery of resources.	Identification of spaces for the collection of waste.

By analysing these two frameworks, commonalities have been identified in order to build a unique proposal more targeted to urban planners, as presented by the arrows in figure 3.

The comparison reveals significant similarities between the two interpretations of the "Regenerate" principle when applied to urban planning practices (indicated by the green arrow in the figure). Both emphasize the protection and restoration of the city's natural capital, the development of green and blue infrastructure, and the integration of nature-based solutions within urban environments.

Another point of convergence is observed between Williams' "Adapt" strategy and ICLEI's "Rethink" strategy (highlighted by the orange arrow). Both approaches stress the necessity of preparing the foundation for profound changes in lifestyles and consumer behavior to guide the transition toward circularity. They envision an adaptive community that is conscious of global challenges and capable of adjusting to change. Flexibility in planning, including temporary use of spaces, multifunctionality of urban areas, co-design of climate change adaptation measures, reuse practices, and temporary experimentation, are integral elements of this vision, which is achieved through active citizen participation and engagement.

Regarding the "Loop" strategy in Williams' framework, it shares similarities with ICLEI's "Rethink," "Reuse," and "Reduce" strategies. As looping actions, the "Rethink" strategy partially addresses the closure of urban metabolism and building refurbishment, while also promoting urban forms that facilitate the operation and expansion of eco-cycles throughout the city, such as high-density development, mixed-use areas, efficient public transportation networks, and district heating systems. Correspondingly, both the "Reuse" and "Reduce" principles are



3. Synergies between the framework of ICLEI and Jo Williams. (Author's elaboration)

interconnected: "Reuse" encourages the reutilization of spaces and supports accessibility to public transport, whereas "Reduce" focuses on enhancing water and energy-saving infrastructure to optimize urban flows and cycles. Lastly, ICLEI's "Recover" principle, when interpreted from a spatial planning perspective, primarily concerns the identification of spaces dedicated to waste collection. Although it can be classified within the "Looping" strategies, its relevance is comparatively lower than the other linked principles.

This analysis suggests that the "Looping" concept effectively combines two principles related to the urban strategy of avoiding consumption of new virgin soil by prioritizing the reuse of existing infrastructure. Meanwhile, "Recover" and "Reduce" serve to support the closing-cycle vision by focusing on the identification of waste collection spaces and infrastructure for water and energy conservation, which are essential components for closing loops at the city or regional scale and exert a significant influence on circular urban development.

3.5. The formulation of inspiring guiding principles

As a consequence of the above reasoning, four principles that summarize and recompose the eight described above are proposed, aiming at clarifying them to policy makers to exhaustively guide a circular transformation of the city. It will support urban planners in interpreting circularity. The four principles are:

4. Four guiding principles to interpret the circular city. A proposal. (Author's elaboration)

Build nothing and reuse infrastructure and soils fostering zero-waste ideal

Reducing the consumption of natural resources and eliminating the concept of waste are fundamental priorities for achieving a circular economy. At the city level, this entails prioritizing and maximizing the use of existing assets within the urban environment. Policies should actively promote the reuse of underutilized or abandoned buildings, areas, and infrastructures before considering new construction or the conversion of agricultural land. This approach is closely linked to the need to assess and enhance accessibility to existing services and goods, often through adaptive reuse practices. The implementation of circular economy principles can mitigate negative externalities such as greenhouse gas emissions, air and water pollution, land and soil degradation, and traffic congestion by optimizing conditions and improving access to the city's existing services. Furthermore, practices of land decontamination should be encouraged. Actions such as reuse, recycling, and recovery are central in this context, focusing primarily on the efficient management of the city's current assets. From this perspective, a circular city can be characterized as equitable, dense, inclusive, rational, and composed of recovered urban spaces.

Regenerate nature and with nature in urban areas

Ecosystem services are vital for sustaining urban systems due to their capacity to regulate microclimates and provide numerous benefits for the health and wellbeing of urban populations. Urban densification has led to the loss of green and blue infrastructure, thereby impairing the provision of these essential ecosystem services. This degradation contributes to increasingly polluted urban environments where the impacts of climate change—such as urban flooding, heat stress, biodiversity loss, and soil degradation—are intensified. The principle of regenerating nature seeks to address the urgent need to restore the ecological components of cities by revitalizing urban ecosystems and their associated services. The implementation of nature-based solutions and the creation or enhancement of green and blue infrastructure, referred to as "regenerating with nature," operationalizes this principle by facilitating the reintegration of natural elements within urban contexts. From this perspective, a circular city is envisioned as regenerative, healthy, and green.

Do better with less, reducing resources exploitation and optimizing the use of spaces

This principle concerns optimisation practices, specifically maximizing the use of existing spaces and infrastructures. The concept of "doing better with less" emphasizes extending and intensifying the lifespan of these assets by using them more efficiently and for longer periods. At the city scale, this principle translates into reducing material consumption and dependence on scarce resources, enabling digital transitions, and promoting multi-functionality to facilitate cooperation among diverse stakeholders. It also reflects the necessity of supporting a paradigm shift in lifestyles and community behaviors, moving from ownership towards sharing practices. Urban farming contributes to this transition by fostering greater self-sufficiency within urban areas, thereby decreasing reliance on limited resources. However, achieving an appropriate balance between urban and rural areas remains crucial in this context. From this perspective, the circular city is envisioned as optimized, efficient, and self-sustaining.

Adapt to change, fostering flexibility, resilience and inclusiveness

Resource scarcity and climate change represent the most significant challenges of our era. Cities are complex systems that evolve in response to changing practices and needs, and they must be designed to withstand increasingly frequent stressors. To achieve higher levels of sustainability, cities need to evolve toward a stable state that differs from their initial conditions. This concept aligns with widely accepted definitions of resilience, which can be fostered through knowledge sharing among urban institutions, communities, and networks. From a planning perspective, it is essential to address the uncertainty facing cities by anticipating change and creating flexible environments that allow urban forms and infrastructures to adapt (Williams, 2021a). Planning should support temporary uses, encourage flexibility, and promote pop-up initiatives, while enhancing the role of cultural heritage through adaptive reuse. Cultural heritage is a driver for urban regeneration pathways and its reuse is substituting the demolition by prolonging the asset lifespan. In this regard, it is a way to conserve natural resources and to avoid new resource extraction. Moreover, adaptive reuse of cultural

heritage can generate circularity in its broader context, by impacting the quality of public spaces and the quality of life of the inhabitants (Gravagnuolo, Monteleone & Fusco Girard, 2024). Furthermore, community engagement in decision-making processes and co-creation with citizens contribute to building an adaptive and resilient community that is more aware of challenges and better equipped to handle uncertainty. Inclusion and participation are crucial to ensuring that planning decisions affecting territorial transformation are collectively agreed upon by stakeholders and citizens. Under this framework, the circular city is envisioned as inclusive, re-creative, adaptive, and resilient.

Discussion of the four principles

The proposed new framework is founded on principles designed to guide policy-makers in envisioning cities through a circular lens, with a specific focus on how spatial planning can effectively shape the transition of cities toward circularity. This perspective distinguishes the model from existing frameworks, which often emphasize other elements such as household waste prevention or goods consumption.

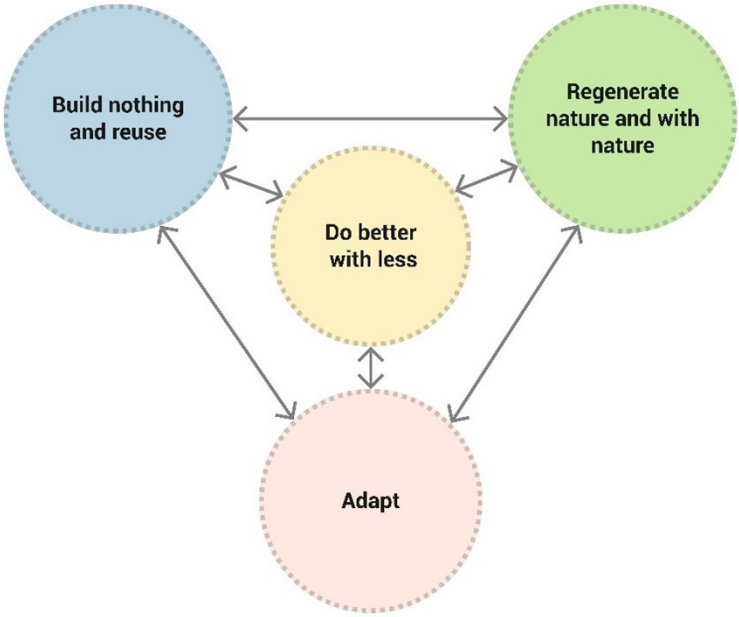
Within this framework, reuse is not primarily about the recycling of products and materials but centers on the reuse of underutilized or vacant public spaces and infrastructures, thereby promoting the principle of avoiding the consumption of new virgin land. For urban planners, reuse represents the most potent strategy to achieve zero waste, where degraded urban areas are considered waste. While closing material cycles is important, achieving zero waste at the city scale is often challenging; however, cities can be designed to minimize energy and water consumption.

Regarding the regeneration of nature and the integration of natural elements within urban environments, the focus lies on introducing green spaces that provide ecosystem services aimed at improving public health and wellbeing. This principle transcends merely regenerating areas to close biological cycles, also addressing the often-neglected aspect of urban health.

The principle of adapting to change emphasizes fostering adaptation, resilience, and inclusiveness. It highlights a paradigm shift in social values, beliefs, and lifestyles, alongside the necessity to manage uncertainty through the multifunctional use of

spaces. In this context, culture is reinforced as a catalyst for urban regeneration and innovation, strengthening local identity and encouraging community engagement. The active involvement of citizens in the planning process is therefore underscored.

The principle of doing better with less addresses gaps in existing models by promoting the digital transition and encouraging shared services, from mobility solutions to housing and workspaces. This approach optimizes knowledge and usage within the city. Consequently, this principle permeates the other three, acting as an enabler of practices that support the realization of all strategies. Moreover, the principles exhibit synergies and mutual influences, collectively contributing to the creation of the circular city, as illustrated in figure 5.



5. Relations between circularity principles. (Author's elaboration)

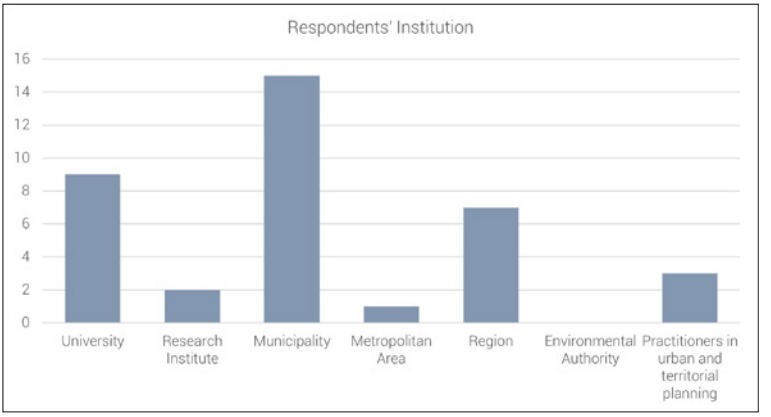
Validation of the four principles

The key principles have been validated through an anonymous questionnaire that has been shared with policy-makers, academia and experts in the circular economy field.

More specifically, the overall methodology has been described, providing details of the interpretation of each principle. Respondents, after giving some details about their working institution and their job position, were asked to express their

opinion about the sufficiency and efficacy of the four guiding principles being aware that the aim of the research is to overcome a vision of the circular city limited to flows management and proposing a more holistic and transversal framework, where the spatial dimension of circularity plays an important role. It has been underlined that the framework should serve to guide the future transformations of the city with a view to circularity, being the principles adapted at the service of policy-makers. The questionnaire has been translated into Italian language in order to enlarge the sample as much as possible. A total of 37 answers have been collected, the vast majority in Italian language (34 out of 37).

The following figure 6 shows that the respondents mainly work in municipalities and universities, and from the job profile it is possible to highlight that the majority of civil servants are working in the urban planning departments, thus dealing with the preparation of new plans for their municipality.



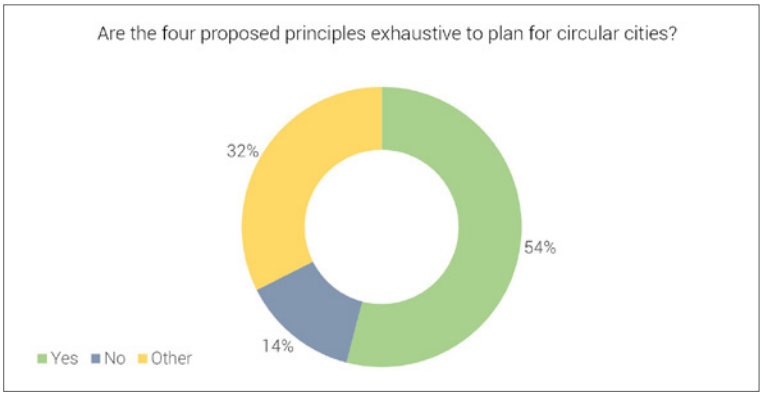
6. Respondents' profile in terms of Institution (Author's elaboration)

When it comes to the validation of the four principles, they have been formulated in a way that was possible for interviewees to understand better their main focus and why they have been considered important in a circular city vision. The principles have been proposed as follows:

1. Eliminate the concept of waste, through the reuse of soils and infrastructures;
2. Regenerate nature and part of the city with solutions inspired by nature, acknowledging the city's regenerative capacity;

3. Improve the effectiveness of solutions by pursuing a lower consumption of resources;
4. Rethink urban areas, planning for adaptability and flexibility.

Answers are summarized in figure 7. 54% of the respondents agree that principles are overall exhaustive. For the remaining 46%, the possibility of letting them write some comments has been precious. In fact, from the motivations they provided in the text boxes, two overall considerations came out: firstly, it became clear that some principles could be finalized and expressed in a clearer and straight-to-the-point way; secondly, many of the proposed additions were indeed too specific to be included in guiding principles. In conclusion, the overall validation of the four principles was successful.



7. Interviewees' opinion about the exhaustiveness of the four proposed principles for planning circular cities. (Author's elaboration)

Thanks to these answers, the principles have been fine-tuned as presented in the previous paragraphs and reported below:

1. Build nothing and reuse infrastructure and soils, fostering the zero-waste ideal.
2. Regenerate nature and with nature in urban areas.
3. Do better with less, reducing resources exploitation and optimizing the use of spaces.
4. Adapt to change, fostering flexibility, resilience and inclusiveness.

The four guiding principles are designed to help policy-makers shape a vision of the circular city by supporting the identification of future-proof strategic pathways for territorial development. In the following chapters, an operational tool is also proposed and the innovative methodology further detailed.

Notes

[1] The Ellen MacArthur Foundation identified a set of six actions that businesses and governments can take in order to transition to a circular economy: Regenerate, Share, Optimise, Loop, Virtualise, and Exchange. Together they represent the RESOLVE framework.
[2] https://assets.website-files.com/5d26d80e8836af2d12ed1269/611cdc96e76d1368c3cff8a6_20210809%20-%20frameworks%20-%20Key%20Elements%20of%20CE%20-%20A4.pdf

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4. A DECISION-MAKING TOOL SUPPORTING SPATIAL PLANNING: EMBEDDING CIRCULARITY INTO THE STRATEGIC ENVIRONMENTAL ASSESSMENT

4.1. The approach

To promote the transition towards circularity at the city scale, it is crucial to focus on the built environment and the natural capital of the city, as well as on the role of citizens in supporting and adapting to this transition. A shift in social behaviour and values is necessary, and this aspect is increasingly relevant at district and neighbourhood levels. Scholars widely agree that a one-size-fits-all approach is inadequate for simplifying and systematizing the operationalization of the circular city concept. Instead, a flexible approach should be pursued, one that establishes the fundamental principles of circularity while allowing adaptation to local specificities in practice. The preservation of diversity and social values is essential for a successful transition, which must be shared with citizens to ensure effective implementation.

The critical role of spatial planning is clearly recognized in the literature (Fusco Girard & Nocca, 2019; Turcu & Gillie, 2020; van der Leer, van Timmeren & Wandl, 2018; Williams, 2020, 2023). For circular processes and synergies to be implemented in urban spaces, they must be integrated within urban planning tools, which serve as instruments for reorganizing cities and, in this context, act as enablers for holistic transformations towards circularity.

Although the concept of spatial planning lacks a universal definition across Europe, the scale of planning significantly influences its application. The term spatial planning encompasses national and transnational planning, regional policies, and detailed land-use planning (European Commission - DR for Regional Policy and Cohesion, 1997). Spatial planning instruments in European countries can be categorized as follows: national policies and perspectives; strategic tools or spatial strategies that identify broad spatial development patterns be-

yond municipal boundaries; masterplans or spatial framework plans closely linked to local contexts and typically enacted at the local scale; and regulatory tools governing land use transformation (European Commission - DR for Regional Policy and Cohesion, 1997; United Nations, 2008).

Within this classification, spatial framework plans appear most suitable for integrating circular-inclusive considerations due to their local scale and strategic nature. The local scale generally corresponds to the lowest governance level responsible for city planning through instruments such as masterplans and regulatory tools. In all Member States, municipalities or associations of municipalities govern the local planning level. These planning instruments, enacted at the municipal level, guide territorial transformation both strategically and structurally. The proposed methodology aims to impact the strategic dimension of municipal spatial framework plans by integrating circularity into the definition of strategies embedded within urban planning procedures and tools.

Spatial framework plans can:

- Provide long-term objectives, principles, and goals.
- Identify future patterns for urban development.
- Serve as a framework for detailed local planning and regulation.
- Connect national and strategic guidance with binding provisions of more detailed zoning plans.

Consequently, the primary urban domains addressed by these plans are:

- The built environment asset (technological domain), encompassing buildings and grey infrastructure for mobility and transport.
- The natural capital of the city, represented by green and blue infrastructures.
- The social capital, which includes governance structures, stakeholders, and citizens.

By adapting urban targets from existing holistic models, this framework aligns with the well-established understanding of the city as a complex socio-ecological-technical system (SETS). In this research context, and similarly to Markolf et al. (2018), the social domain includes both actors, with their roles and activities, and institutions. Governance, cultural values, tacit knowledge, financing, policies and regulations, and citizens are

all components of the social domain. At a finer scale, education, communication, lifestyle choices, and decision-making processes are also included, as they shape public understanding and engagement. The ecological domain comprises the environment, its functions (e.g., food production, climate regulation, nutrient cycling), and behaviours, including efforts to protect, maintain, and restore ecological elements that provide ecosystem services, thereby enhancing human wellbeing and mitigating climate change impacts. The technological domain encompasses physical and digital infrastructure, as well as software and decision-support systems (Grabowski et al., 2017; Markolf et al., 2018). These three components are deeply interrelated; for example, land use practices fall within the ecological domain since soil is a finite natural resource, but how soil is managed and utilized is also inherently tied to the social domain.

Once identified spatial plans as suitable tools to integrate circular economy principles, the following paragraphs will present the methodology itself, which consists in an innovative interpretation of the Strategic Environmental Assessment procedure.

4.2. The strategic environmental assessment, an overview

Many European directives and policies provide flexible frameworks that influence spatial planning due to their binding nature (European Committee of the Regions et al., 2018). European regulations focus on thematic areas such as environmental impact assessment, energy consumption, maritime legislation, territorial cohesion, rural development, territorial cooperation, and urban and transport policies (ESPON, 2018). Among these, the Strategic Environmental Assessment (SEA) Directive and the Environmental Impact Assessment (EIA) Directive have a clear and direct impact on spatial planning by requiring urban transformations to meet environmental sustainability criteria and mitigate potential negative effects. While other directives, such as the Flood Directive, also affect spatial planning, the SEA and EIA directives uniquely impose binding procedures on Member States.

The SEA specifically aims to evaluate the environmental impacts of policies and plans, addressing potential harm to natural components like soil, water, air, flora, fauna, cultural heritage,

and biodiversity. Its overall goal is to promote sustainable development and ensure a high level of environmental protection. The directive's transposition varies across Member States, reflecting national governance specificities to achieve the highest environmental standards (Cerreta & De Toro, 2012; McLauchlan & João, 2012).

Importantly, SEA is designed as a proactive process to support the drafting of plans and programmes, integrating environmental and sustainability considerations early in decision-making rather than assessing them after adoption (Cerreta & Russo, 2023; Fischer, 2010; Floris et al., 2023). Although SEA's effectiveness has varied (Cerreta & Russo, 2023; Lodrini, Anghinelli & Ronchi, 2023; Mazzeo, 2023; Tondelli, 2013), recent successful examples demonstrate its flexibility to address emerging challenges such as climate change mitigation, adaptation, and biodiversity loss (Commission & Environment, 2013; European Union, 2013; Floris et al., 2023). Scholars and practitioners advocate for a broader, more strategic interpretation of SEA to address long-term sustainability issues including social challenges and overpopulation (European Commission, 2019; Office of the Deputy Prime Minister, 2003).

SEA's impact tends to be greater at local governance levels, where spatial planning is more detailed and data availability is higher, compared to higher-level plans and programmes (European Commission, 2019). Detailed assessments benefit from extensive baseline data such as population trends and geographical contexts, which facilitate informed decision-making.

Recognizing the need to assist policy-makers without creating new bureaucratic burdens, an innovative circular economy-oriented interpretation of SEA has been proposed to address circularity at the local scale. SEA's existing legal framework, already familiar to practitioners, offers adaptability to local needs and emerging challenges, making it a practical tool for integrating circular economy principles into urban planning with minimal additional costs or procedural complexity.

SEA is primarily considered a decision-support tool. The following guidelines and examples aim to integrate SEA's procedural steps into circular-inclusive urban planning, helping policy-makers recognize the role of circular economy in sustainable urban development and providing a clear process for adoption.

STAGE A: SCOPING

A1: Identification of the scope of the plan: baseline information and objectives of the plan

A2: Identification of relevant policies, plans and programmes for the assessment of the internal and external coherence and the tool to support these appraisals

A3: Identification of the environmental problems and trends without the implementation of the plan

A4: Development of the **SEA objectives,** established at international, community or member state level

A5: Stakeholders' consultation on the scope of the assessment

STAGE B: preparing the environmental report considering planning alternatives

B1: Testing the plan objectives against the SEA objectives (external coherence with higher-tiers appraisal)

B2: Internal Coherence appraisal, within the various objectives of the plan

B3: Development of strategic alternatives

B4: Assessment of alternatives and of the effects of the preferred option

B5: Introducing mitigation measures for potential adverse effects

B6: Develop proposal for monitoring the environmental effects of the plan

STAGE C-D: Consulting phase and decision-making

C1: Consultation on the plan and the environmental report

C2: Appraising significant changes after consultations

C3: Informed Decision-making and justification of the choices

STAGE E: Monitoring

E1: Monitor the significant effect of the plan to identify unforeseen effects

E2: Responding to adverse effects

CONSULTATION WITH AUTHORITIES AND PUBLIC

8. Details of the SEA stages. Author's elaboration based on (European Union, 2001) as also adapted in Ioppolo et al., (2019).

Historically, both SEA and EIA originated in the United States in the 1980s to assess potential environmental impacts of plans and projects. The EIA Directive (85/337/EEC) was the first to be adopted in Europe, focusing on significant public and private projects. The SEA Directive (2001/42/EC), introduced in 2001, specifically targets plans and programmes, and was implemented by Member States by 2004, although delays occurred. The SEA Protocol, adopted in 2003 under the Convention on Environmental Impact Assessment in a Transboundary Context, provides an international framework for SEA (United Nations, 2003).

The SEA Directive aims to integrate environmental considerations into the preparation and adoption of plans and programmes with significant environmental effects, promoting sustainable and effective decision-making by including relevant environmental information early in the process (European Commission, 2001).

The directive also defines which plans and programmes require assessment and which may be exempt through a screening procedure. Most spatial, town, country, and land use planning documents are subject to SEA, followed by water management, transport, rural development, and energy plans (European Commission et al., 2016).

The SEA procedure generally includes the following key stages: scoping; preparation of the environmental report considering planning alternatives; public consultation; decision-making; and monitoring (European Commission webpage, n.d.; European Union, 2001; Ioppolo et al., 2019).

The scoping phase is aiming at understanding the scope of the plan through the collection of external factors that can affect the proposed strategies and the identification of relevant programmes and environmental protection objectives. Making a parallel with the process of plan-making, the gathering of baseline information starts in this early stage and the potential environmental problems are explored. The environmental sustainability framework is identified, representing the means to assess the environmental performance of the plan. It represents how the plan is assessed in terms of environmental effects, and describes how these latter are identified, analysed and compared. The first draft of the objectives of the plan is defined and

consultations are usually occurring together with the Environmental authority to ensure that the significant potential negative impacts of the plan are considered. The plan objectives are those selected by the political government in charge of adopting the plan, usually through a process of public and experts' consultation, but they express their vision for the territory. The objectives of the plan are in principle different from the environmental sustainability objectives, even though they may overlap in some cases. Since governments are required to permeate their objectives with sustainability considerations, the overlapping is possible and environmental sustainability objectives may help promoting ideas to achieve it. Local planners must take into account also external objectives coming from other plans and strategies that, if binding must be respected and the plan objectives have to be coherent with them.

Scoping report also includes the list of authorities and entities that might have a stake in the decisions included in the plan, specifically targeting environmental authorities and institutional actors (e.g. regions, other municipalities).

After having framed the state of the art of the territory, having defined the objectives of the plan and the environmental protection objectives, the preparation of the environmental report starts. In this phase the coherence between the objectives of the plan and the environmental protection objectives is conducted, together with the assessment of internal consistency between the various objectives of the plan.

The Directive also requires the development of "reasonable" planning alternatives that should be described and assessed in the environmental report. In many Member States the "zero alternative" is always considered, meaning that at least the scenario in absence of the plan has to be considered and used for comparison.

Once alternatives have been explored and assessed, the choice on the most appropriate planning scenario occurs and its possible environmental effects on resources like soil, air, water and on population, flora, fauna, biodiversity, cultural heritage and landscape are described, together with conditions to the transformation or mitigation actions.

Consultations of the environmental report is required by the Directive which, however, is not mentioning specific timing for

consultation. It is only written that consultations have to be conducted in "*appropriate time frames*". General public and consultation bodies have the opportunity to express opinions and comments on the environmental report, giving feedback on the actions of the plan. This stage is foreseen in a sufficient time before the plan is adopted and the legislative procedure starts, in order to be able to implement changes. In fact, consultees' opinions should be used to improve the plan that will be shaped in its final form, ready to be adopted by the competent public authority. All the comments received during consultations have to be evaluated and, if not implemented in the plan for any motivation, a reasoned opinion should accompany the consolidated draft.

In terms of citizens' involvement, the SEA Directive is encouraging and enabling citizens' participation at strategic level. It is also a tool to empower citizens in taking part of policy-making and planning their territory as well as increase their awareness about environmental sustainability. Notwithstanding, more efforts are needed to increase engagement and an effective co-design of the strategic dimension of the plan (European Commission, 2019). Indeed, it is true that there is the requirement for public participation, but there is no requirement that considerations coming from consultations will shape the design of the plan (Acharibasam & Noble, 2014).

Together with the assessment of alternatives, the monitoring of the effects of the plan is one of the most challenging steps of the procedure. The Directive imposes to develop a monitoring scheme and methodology to track the environmental effects that the plan is producing to show whether they are as predicted in the environmental report. If substantial gaps are identified, actions must be undertaken in order to modify the plan. Indeed, the response to adverse effects should be appropriate and timely. Successful experiences are rare in this regard and environmental monitoring often stops after the adoption of the plan (European Commission, 2019; Lodrini, Anghinelli & Ronchi, 2023). In fact, in order to be successful, a monitoring strategy should identify a responsible subject for the task, who has the role of preparing a report according to a specific timeframe agreed in the environmental report. A communication and dissemination strategy for the results included in the report should be prepared, as well as procedure for assessing corrective

actions, modification or variations of the plan (Lodrini, Anghinelli & Ronchi, 2023).

The compliance of the SEA with the procedures included in the Directive, does not necessarily reflect the ability and effectiveness of the SEA in terms of its real influence on decision-making and its outcome (Acharibasam & Noble, 2014). The characteristic that makes the SEA really effective is that the process has to be integrated into the decision-making since the beginning.

4.3. The circular-inclusive SEA: a proposal

At present, resource efficiency, circular economy, climate change mitigation and adaptation, sustainable cities, and soil protection are not explicitly addressed within the SEA Directive, although the SEA is recognized as making a significant contribution to the prevention of biodiversity loss and the protection of natural capital (European Commission, 2019). Addressing this gap, the proposed methodology aims to overcome these limitations by adapting the established SEA procedural steps to incorporate themes, objectives, and procedures pertinent to circular economy principles. If adhered to, this approach will result in a circular-inclusive spatial framework plan. Through the integration of circular economy considerations into the SEA process, the overarching objective is to facilitate a multidisciplinary assessment of spatial framework plans that accounts for the multidimensional nature of sustainability, encompassing social, economic, environmental, and cultural dimensions.

The proposed circular-inclusive SEA constitutes a strategic and qualitative level of appraisal that considers significant aspects of circular economy related to spatial plans. Building upon the requirements of the SEA Directive, this approach enriches the assessment by introducing integrative objectives, and diverse implementation strategies. Furthermore, the methodology envisages stakeholder participation to highlight key environmental, circular economy, and sustainability constraints. The circular-inclusive SEA also provides guidance on monitoring the effects of the plan, thereby incorporating the final stage of the proposed methodology.

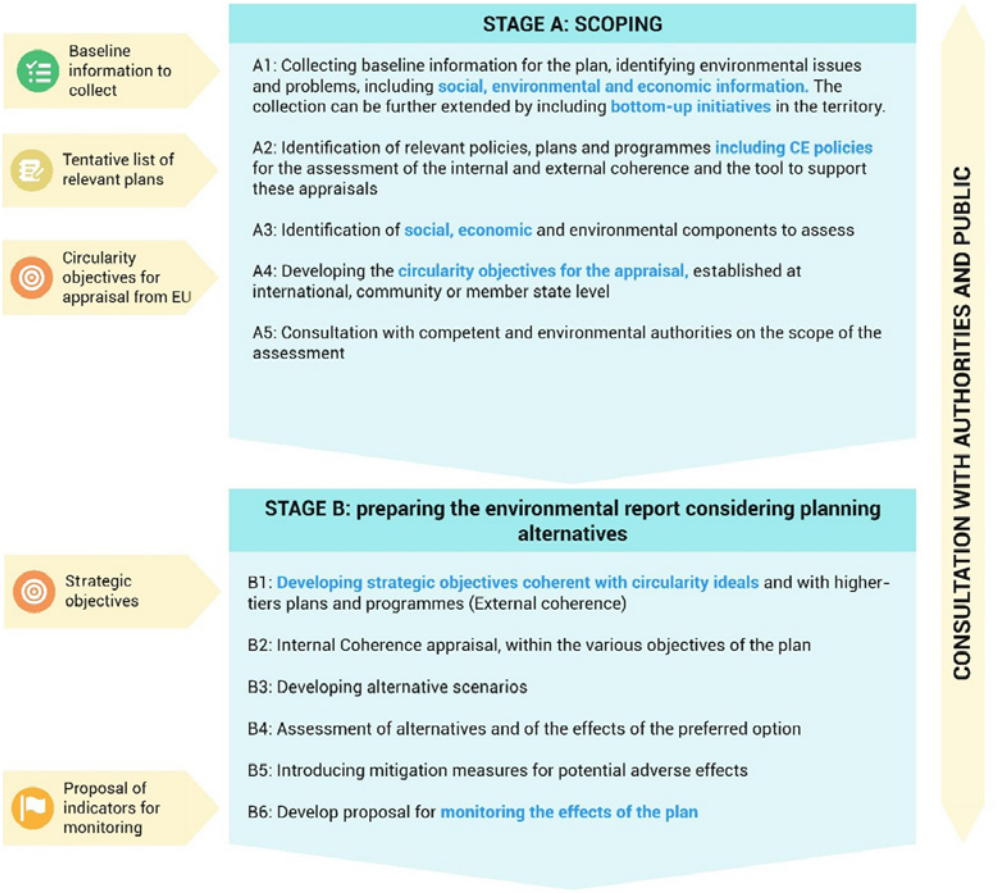
Drawing on and adapting the integrative assessment framework for local development plans proposed in the English context (Office of the Deputy Prime Minister, 2004), the present circular-inclusive SEA proposal is founded on the following principles:

- **Objectives-led:** The framework establishes clear objectives to define the direction of the desired changes, which can subsequently be monitored through specific targets.
- **Iterative:** The assessment procedure is organized into distinct, successive stages that can be revisited if circular economy criteria are not satisfactorily met. Decision-making processes should follow this iterative scheme, resulting in a more comprehensive evaluation of circularity.
- **Data and evidence-based:** Spatial plans are grounded in a baseline analysis to identify local trends and challenges. Access to enriched data enhances the baseline, thereby improving the capacity to measure and monitor the plan's circular economy impacts.
- **Inclusive and innovative:** Inclusion must be promoted both within governance structures and among the public and stakeholders. Circular economy assessments typically require cross-sector collaboration across municipal departments. However, the prevailing tendency to operate in silos constitutes a significant barrier to achieving circular urban development. Early inclusion of citizens and stakeholders, facilitated by innovative and digital tools, fosters greater participation and enhances plan implementation.
- **Timely:** The assessment process must be aligned with the plan preparation timeline to ensure that results are available for prompt integration.
- **Transparent:** Decisions should be guided by a clear, straightforward methodology accessible to non-expert audiences.
- **Useful:** The framework must provide clear conclusions and actionable recommendations for enhancing the circularity of the plan and for the subsequent monitoring of its effects.
- **Multi-dimensional and multi-criteria:** The assessment must address the plan's social, economic, and environmental effects across multiple urban dimensions. Accordingly, diverse criteria, tools, and indicator types should be employed to capture the varied nature of the plan's potential impacts.

As outlined in the introduction, this proposal does not establish a new framework but rather integrates circular economy-related considerations into existing, well-established procedures. Specifically, two stages are crucial for rendering spatial framework plans circular-inclusive: the scoping phase and the preparation of the environmental report, which correspond to the initial phases of plan-making. Conversely, the consultation and plan adoption phases are procedural steps undertaken by public authorities once strategic decisions and actions are defined; thus, these latter stages do not require integration within the proposed methodology.

An analysis of the SEA Directive's requirements for scoping and environmental report preparation reveals that fundamental aspects supporting the integration of circular economy approaches into spatial plans are overlooked, as the focus remains exclusively on environmental impact assessment. The proposed methodology seeks to expand the original environmental scope of SEA toward a broader sustainability assessment encompassing economic, social, cultural, and institutional dimensions. Circular economy principles permeate every step that policy-makers must undertake when drafting plans. The scoping phase should elucidate the plan's scope and identify relevant circular economy targets to be pursued locally. The methodology recommends considering relevant higher-tier policies on circular economy to incorporate their targets into the appraisal framework, thereby ensuring coherence between the plan's objectives and overarching sustainability and circular economy goals.

To assist decision-makers, the methodology provides a list of circular economy objectives aligned with global policies and agreements. These objectives must be tailored and prioritized according to local conditions. This approach offers a flexible vision adaptable to diverse contexts, thereby reinforcing the physical, cultural, and environmental values of localities. Consequently, some objectives may be irrelevant in certain contexts, depending on municipal characteristics. To integrate circular objectives effectively, a detailed baseline framework of the territory must be developed during the scoping phase to inform and support the formulation of circular economy strategies. Relevant information to be gath-



9. A proposal for the circular-inclusive SEA.

ered aligns with the four circular economy principles outlined in the preceding chapter.

Following the formulation of circular objectives, the methodology proposes assessing internal coherence within the plan and external coherence with other policies. Additionally, a tentative list of indicators is suggested to evaluate the performance of the circular spatial plan.

This overview is synthesized in figure 9, where all proposed procedural integrations to the existing SEA process are highlighted in light blue. Orange arrows on the left of the figure represent new circular economy-specific inputs provided to policy-makers to guide their planning strategies and actions toward these principles and practices.

For each of the two most significant circular-inclusive phases more details are provided in the following chapters.

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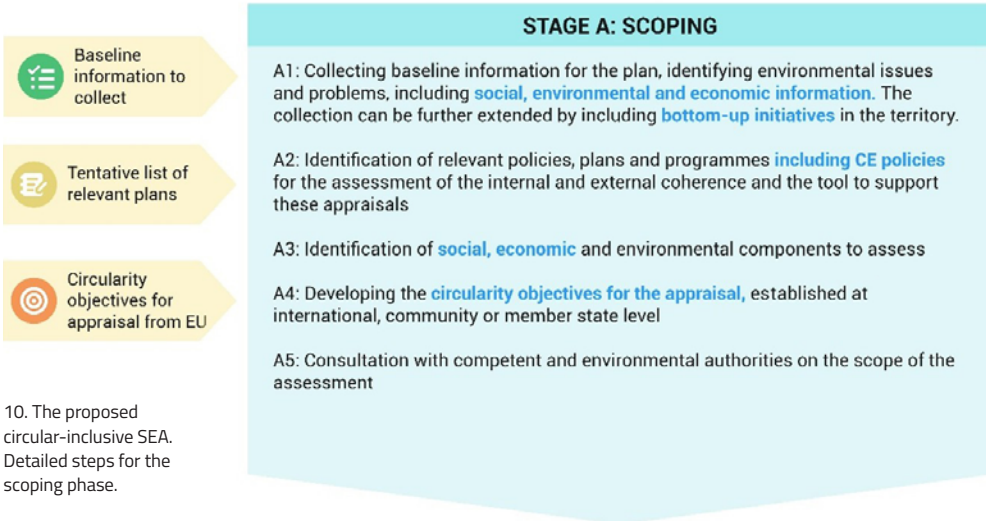
5. BASELINE INFORMATION AND CIRCULARITY FRAMEWORK FOR THE APPRAISAL ENRICHING THE SCOPING PHASE*

The scoping phase is aiming at understanding the context and establishing a baseline according to which spatial plan will be assessed. In this regard, the SEA scoping stages mentioned above, have been integrated as follows.



10. The proposed circular-inclusive SEA. Detailed steps for the scoping phase.

5.1. Baseline information to collect

Spatial plans typically include demographic trends and analyses of the dynamics of the city's main economic sectors, as they aim to match supply with hypothetical demand, such as for housing and infrastructure. Consequently, a baseline framework is usually developed to support the definition of planning strategies. However, this framework can be further enriched by incorporating core aspects that policy-makers require to effectively guide strategies toward a more circular urban environment. In this regard, highlighting both the potential opportunities and

* Part of the chapter has been published in Tondelli, S. & Marzani, G. (2025) How to plan for circular cities: A new methodology to integrate the circular economy within urban policies and plans. *Sustainability*, 17, 5534. https://doi.org/10.3390/su17125534

strengths of the territory, as well as its threats and weaknesses, provides a comprehensive picture of the current state of the area. This overview facilitates the identification of priorities and informs strategic planning. Additionally, an analysis of exogenous factors can assist local administrations in developing alternative scenarios, which will be assessed in subsequent phases of the appraisal process. Ideally, the baseline framework should reveal both the territorial potentials and threats, as well as the current status regarding the achievement of goals and targets established at higher governance levels.

As discussed in Chapter 3, §3.5, four guiding principles serve to interpret circularity within urban planning tools: (i) building nothing new and reusing existing infrastructure and soil to promote the zero-waste ideal; (ii) regenerating nature and working with nature within urban areas; (iii) doing better with less by reducing resource exploitation and optimizing space utilization; and (iv) adapting to change by fostering flexibility, resilience, and inclusiveness. These four principles provide a conceptual foundation for determining the types of information necessary to construct a baseline framework that supports circular-inclusive strategies. To organize this discussion, the required information has been analyzed across social, ecological, and technological domains, consistent with the approach proposed in §4.1. The following table summarizes the information to be mapped, as detailed in the subsequent paragraph.

Tab. 7. Information to be mapped in support of a circular approach. (Author's elaboration)

	Social domain	**Ecological domain**	**Technological domain**
Build nothing and reuse	Quality of existing public spaces and infrastructure. Accessibility to existing infrastructure, green areas and public services, also with regard to fragile groups. Social housing quality and sufficiency. Existing economic activities already related to CE and their accessibility.	Brownfields ecological status.	Enlighten the potential of reuse through the map of abandoned or un(der)used buildings. Quality of the built environment and expeditious materials stock analysis. Existing energy communities, waste treatment plants, centres for the reuse of goods, sustainable water drainage already in place.
Regenerate nature and with nature	Cultural ecosystem services offer. Accessibility to green and blue infrastructure.	Health of ecosystems. Regulation offered by ecosystem services.	Existing NBS and the ecosystem services they provide.
Do better with less	Sharing practices like bike-sharing and car-sharing offer. Public transport efficacy. Timing of the city activities	Provisioning ecosystem services offer.	Density of mix-uses. Industrial symbiosis processes. Access to digital technologies and smart working.
Adapt to change	Existing bottom-up initiatives related to CE. Existing collaboration agreements for the care of urban commons.	Cooling capacity to regulate urban heat island effect. Risk assessment towards natural disasters.	Places where to set urban multi-functional hubs. Cultural initiatives for the innovative use of spaces.

Social domain analysis in support of a circular approach – information to be collected

According to the first key principle of circularity, the reuse of existing infrastructure and soils must be prioritized. This entails assessing and promoting the current quality, quantity, and accessibility of these assets. The overarching objective is to maximize and optimize the use of existing resources before designing and constructing new infrastructure. In alignment with this circular reuse approach, it is essential to map the proximity of the population to existing public spaces, green areas, and public facilities, with particular attention to vulnerable and fragile groups, such as older adults and children. The analysis should identify areas where access to public facilities is achievable without reliance on private vehicles. Additionally, qualitative assessments of public services, including social housing, are crucial, as

the quality and sufficiency of these services significantly influence users' experiences.

To encourage reuse practices that contribute to sustainable lifestyles, it is important to allocate land for facilitating the exchange of second-hand products and materials. Therefore, it is necessary to identify whether circular economy-related economic activities exist within the city, their locations, accessibility, and spatial distribution. Such activities include repair shops, leasing services, and second-hand markets. Examples of circular business models include charity shops; electrical equipment repair services; vehicle hire and rental; second-hand vehicle sales; clothing and shoe repair; clothing alteration and tailoring; clothing hire; household goods repair; leasing of personal goods; farm shops with pick-up services; linen hire and laundry services; and restoration and preservation in construction. The presence and spatial arrangement of these services represent significant drivers of circularity, as they have the potential to influence consumer behavior.

Regarding the principle of regenerating nature and working with nature, the social dimension pertains to the benefits provided by cultural ecosystem services for human health and wellbeing. Although further details on this concept are addressed in the ecological domain, policy-makers should specifically map the accessibility of green and blue areas within the city to identify where improvements are necessary. Ensuring access to these areas is fundamental to enabling cultural ecosystem services. Furthermore, it is important to understand the types of cultural activities occurring within these green and blue spaces, as well as the roles played by cultural associations in this context.

The principle of doing better with less is particularly relevant to the social dimension, given that resource optimization and space utilization are closely linked to citizens' behaviors and lifestyles. A circular economy vision necessitates the development of adequate infrastructure and the promotion of shared, low-carbon mobility solutions. To devise coherent strategies, it is essential to assess the effectiveness of sharing practices, such as car-sharing and bike-sharing services, by evaluating both their accessibility and the quality of infrastructure supporting low-carbon mobility. The efficiency of public transportation

systems also plays a critical role in optimizing shared mobility solutions. Moreover, space optimization is crucial in a circular city, which should be understood not only spatially but also temporally, considering the timing and duration of space usage. A comprehensive understanding of current practices regarding underused or unused spaces and infrastructures is necessary to propose solutions that enhance flexibility and optimization.

The final principle, adapting to change through fostering inclusiveness, flexibility, and resilience, must also be integrated into urban planning. From a social perspective, this involves promoting pop-up initiatives, temporary uses, and the active inclusion of citizens in planning processes to build circular communities. This requires strong collaboration with residents and the development of initiatives encouraging their participation in civic life and public space stewardship. Accordingly, existing bottom-up initiatives for the administration of urban commons should be mapped, assessing their locations, city-wide impacts, and the circularity principles they primarily address.

Ecological domain analysis in support of a circular approach – information to be collected

The interpretation of the "build nothing and reuse" principle within the ecological dimension emphasises avoiding the consumption of new virgin soil and instead promoting land decontamination practices aimed at the regeneration of brownfield sites. These brownfield areas represent a significant resource for circular urban development, as they are typically situated in highly accessible urban locations. The primary barrier to their reuse lies in potential soil contamination resulting from previous industrial activities. Therefore, it is strongly recommended to establish a comprehensive framework assessing the current quality status of these areas, alongside an evaluation of their potential for transformation, particularly regarding circular activities that could be established there.

The principle of "regenerating nature" exerts the most influence within the ecological domain. The Strategic Environmental Assessment (SEA) Directive already addresses key ecological concerns, including climate status, soil degradation, biodiversity (flora and fauna), water and air quality, and natural habitats. To reinforce the interconnection between the social and ecolog-

ical components of the city, it is proposed not only to map the condition and health of these ecosystems but also to analyze the benefits they provide to the social sphere. Such an approach can inform policy-making by fostering strategies that simultaneously promote ecosystem quality and enhance human health and wellbeing. Cultural, regulating, supporting, and provisioning ecosystem services offer numerous benefits, particularly regarding health and wellbeing (Millennium Ecosystem Assessment, 2005). Supporting services are foundational for the production of all other ecosystem services; unlike provisioning, regulating, and cultural services, their impacts on people tend to be indirect or occur over extended timeframes, whereas the effects of the other categories tend to be more direct and immediate (Millennium Ecosystem Assessment, 2005).

Green and blue infrastructures, which provide essential ecosystem services in urban areas, are increasingly critical to addressing major urban challenges, including climate change adaptation and decoupling urban growth from the consumption of finite resources to foster circular and resilient cities and communities. Among the available methodologies to assess ecosystem services, analyzing the balance between demand and supply is particularly suited to inform and evaluate urban policies (De Luca, Martin & Tondelli, 2021; Wolff et al., 2015). The identification of mismatches between the demand for and the supply of ecosystem services offers vital information to tailor urban policies and develop strategies aimed at reducing gaps in areas where demand significantly exceeds supply. Urban planning decisions affect both demand and supply: supply is contingent on the availability, location, and quality of ecosystems, while demand depends on population density, availability of public spaces, and their functions (Geneletti et al., 2019). Given the varying meanings of ecosystem service concepts depending on the specific service analyzed, assessment methodologies must be adapted accordingly and constrained by data availability (Wolff et al., 2015). It is therefore advisable for local decision-makers and their transdisciplinary teams to identify the ecosystem services most pertinent to their planning area and to align urban policies with the outcomes of these assessments. In accordance with the "regenerating nature" principle, particular emphasis should be placed on regulating ecosystem services, es-

pecially carbon storage and sequestration, as well as the capacity of vegetation to capture pollutants.

Regarding the "doing better with less" principle, the focus shifts toward optimizing the supply of provisioning ecosystem services, with particular attention to urban and peri-urban agricultural activities, which should be identified and spatially mapped within cities.

Finally, under the principle of "adaptation," policy-makers should promote the expansion of nature-based solutions (NBS) infrastructure in urban areas to manage extreme climate-related events. This includes mapping the cooling capacity of urban ecosystems to evaluate the city's ability to mitigate the urban heat island effect and to guide interventions in the most affected zones or areas inhabited by vulnerable populations. Air quality regulation is also critical in urban settings experiencing elevated pollution levels. In addition to ecosystem service assessments, the production of risk maps is encouraged, including flood risk and seismic hazard analyses. These maps should focus on the three components of risk: exposure, vulnerability, and hazard. This tripartite framework provides a valuable basis for directing planning strategies, particularly by reducing exposure through land-use prescriptions and incentives aimed at decreasing the vulnerability of the built environment.

Technological domain analysis in support of a circular approach – information to be collected

As mentioned in §4.1, the technological dimension of the city is related to buildings and grey infrastructures, such as water and transport infrastructures, industrial systems and energy systems. The analysis is usually including the structural asset of the territory.

Assessing the technological component according to the "build nothing and reuse" principle of the circular economy involves highlighting the potential for reusing existing spaces and infrastructure, as well as identifying synergies between different sectors. This approach aligns with the overarching goal of promoting a zero-waste ideal. Although the analysis of urban metabolism provides a foundational understanding, it remains insufficient on its own as it lacks explicit spatial implications. Within this context, the zero-waste ideal is interpret-

ed in both physical and functional terms. Firstly, municipalities must undertake comprehensive mapping of abandoned infrastructure within their territories to gain an overview of unexploited spatial potential. Secondly, renovation efforts should be prioritized to condition the construction of new infrastructure on the reuse and maintenance of existing assets. Consequently, it is necessary to map the condition of the built environment in terms of quality, aesthetics, energy efficiency, and seismic performance.

Mapping the material stock within the built environment is equally crucial, as it supports the development of plans for the disassembly and reuse of materials and components from existing public infrastructure in the construction of new infrastructure. To minimize waste generation, urban mining combined with spatial analysis can facilitate the identification of locations suitable for temporary material storage, recycling centers, or remanufacturing facilities, while also optimizing transportation demand. Scientific studies indicate that an expedited assessment of material stocks in urban areas is feasible based on data already available to municipalities, such as building typologies and dimensions. From this information, it is possible to estimate the potential quantities of materials (measured in kilograms per useful floor area) available at the end of their lifecycle (Marinova et al., 2020).

Furthermore, when applicable and relevant, existing infrastructure that influences new developments in pursuit of the zero-waste ideal should be identified and spatially located. This includes energy communities that facilitate energy sharing, waste treatment plants, goods reuse centers, and sustainable drainage systems already in operation. These infrastructures aim to minimize the negative externalities of new developments, though it should be noted that the complete closure of material cycles is unlikely to be achieved solely at the municipal scale.

Regarding the principle of "regenerating nature and with nature," this aspect primarily concerns the technological dimension through the integration of nature-based solutions (NBS) and sustainable drainage systems. Due to the multifunctionality of NBS in urban environments, the mapping and assessment of these systems correspond closely with those described within the ecological dimension.

Focusing on the "do better with less" principle, optimization emerges as the key objective for the technological dimension. In terms of space utilization, it is essential to ensure mixed uses and a diversity of accessible services within walking or biking distance. Additionally, where relevant, existing industrial symbiosis processes should be identified and mapped. Optimization also entails fostering the digital transition; therefore, municipalities should map broadband accessibility and assess the prevalence of smart-working practices within public administrations where applicable.

Aligned with the principle of adaptability in the technological domain, it is necessary to encourage flexibility in the built environment, particularly regarding its functional use. Consequently, analyses should focus on identifying spaces suitable for the development of urban hubs capable of accommodating diverse functions that respond to evolving needs and serve multiple purposes, such as social inclusion and climate adaptation. Case study analyses demonstrate that cultural activities serve as catalysts for innovation and the adaptive reuse of spaces, while also promoting citizen participation and fostering a sense of place. Governance experimentation in managing these spaces collaboratively and inclusively is also recommended. Mapping cultural initiatives within the city's open spaces helps identify areas that are socially vibrant as well as those requiring incentives to stimulate similar practices. These analyses are also connected to the recognition of cultural ecosystem services when natural and semi-natural areas are included in consideration.

General consideration about the type of data and tools to be collected

As seen into the previous paragraphs, to have a comprehensive overview and orient the baseline framework in order to include circularity information, some specific analyses are recommended. It is therefore necessary to involve specialists with competences in different fields such as environmental analysts, sociologists, health professionals. The multidisciplinary approach is to be fostered in order to reflect the complexity and richness of the state of the art into a more inclusive and multi-purposes strategy for the city.

Baseline information can be both quantitative and qualitative. If quantitative, data would be probably in possession of the

local authorities, coming from monitoring framework already in place or collaborations with research centres, universities, territorial entities, environmental authorities and institutes, national statistical departments. As for the qualitative information, cooperation with local actors like associations of the third sectors and citizens is crucial to obtain a realistic picture of the state of the art of the territory. The criteria followed to determine the qualitative assessment have to be clear, easy to understand and transparent, in order to be replicable.

Information can also come from other legislations and higher tiers strategies and tools that include indications useful to set out the context for the plan and through collaboration with consultation bodies, including the environmental ones.

This circular specific analysis has spatial resolution and must be joined with statistical information about the population, i.e. the economic status, demographic trends, health situation, levels of education, employment rates, crime rates. Also, GDP per capita has to be monitored, and it is overall important that a spatial distribution of these social dynamics is provided in the baseline framework.

Building the baseline framework for spatial plans implies to use maps in order to visualize information in a proper and useful way to build a strategy. Geographical Information Systems (GIS) are particularly useful in this context, since the overlapping of different layers of information allows to elaborate more interesting considerations coming from the interrelation of different datasets. Physical phenomena can be linked to socio-economic dynamics in order to relate some trends with specific locations. When possible, the collection of data over time has to be fostered, since it is important to examine historical tendencies in order to build predictions for the near future. This information may support the definition of scenarios, like the “do nothing” and “business as usual” ones. The “do nothing” scenario implies that no further development or transformation is allowed in the area, while the “business as usual” might mean the continuation of the actual plan. This type of analysis has the advantage of identifying and potentially foreseeing the existing and future social, environmental and economic issues.

BOX A1: The importance of a structured baseline framework – The Emilia-Romagna region example

The Emilia-Romagna region included in the urban planning law no. 24/2017 the necessity of elaborating a diagnostic baseline framework, in order to achieve a profound degree of knowledge of the local contexts, and make regeneration strategies targeted to the territories and their specific needs. In addition, in the law it is also mentioned the "urban metabolism" as a component to analyse in the baseline framework. It represents an attempt of giving increasingly importance to topics inherent to circularity theories. However, municipalities still lack information about how the urban metabolism should be assessed and for which purposes.

The regional guidance on how to conduct the SEA for local urban plans, is also proposing the use of the SWOT analysis to analyse the different components of the city, providing a synthetic but exhaustive overview of the actual status of the territory, enlightening the vulnerabilities and resilience factors of the area.

Besides the urban metabolism analysis, the assessment of ecosystem services is also fostered by the regional law.

In terms of stakeholders' involvement, and it is already firmly established by the Directive that environmental and public authorities have to be included into the consultation about the scope of the plan. However, in the interpretation of the SEA as a decision-making process, public participation is essential also in the definition of the strategies of the plan. As encouraged by the circularity principle of adaptation, the formation of circular communities has to be encouraged, intended as group of citizens with a keen sense of place, aware of the challenges of the territory and informed about the importance of embracing the change towards circularity. To this aim, the involvement of the third sector and citizens for the co-design of strategies is essential. Their participation in the design phase of the plan, plays a crucial role in the experimentation of innovative models of the governance, in which for example active citizens can manage urban commons through Collaboration Agreements with the public Administration. Participation is thus intended in its broader sense, with the real cooperation between the two actors in co-programming and co-designing projects and initiatives for the care and regeneration of urban commons. The importance of including citizens into decision-making since the very beginning is also reflected into the implementation phase of the actions of the plan. As an example, civic crowdfunding is being increasingly considered as an innovative tool to finance projects that are of important value for the local community who believes in the initiative strongly enough to finance part of it (Lee,

Zhao & Hassna, 2016). By proposing into the strategy projects that are shared with stakeholders and citizens can enhance the efficacy of this tool, that can also positively enter into the economic feasibility of the plan.

In this context, innovative and digital tools represent an opportunity, enabling an easier access to information, an easier way to collaborate and facilitating the creation of citizens' awareness about the value of circularity and how to enhance it.

5.2. List of relevant policies and plans for the appraisal

After the identification of stakeholders to involve and having conducted a diagnostic baseline framework, the methodology foresees to assess relevant policies and targets concerning circular economy in order to build the framework for appraisal. The identification of circularity strategies and specific objectives coming from higher governance levels represents the starting point, inspiring the formulation/adaptation of the strategies of the plan that should be already coherent with those ones. This passage implies the application of the SEA in an endo-procedural way, by accompanying the draft of the plan since the beginning. Obviously, European and global targets put in place in terms of sustainability cannot be excluded in the assessment. Concerning the first ones, the EU level indications included into the New Circular Economy Action Plan are highly relevant, as well as additional targets that might be identified at national or regional levels by each member states (e.g. the national strategy for circular economy adopted in Italy). At global and European level, the Agenda 2030 with its SDGs is the reference framework, together with the European Green Deal and the European Biodiversity Strategy. This list of plans and policies, even though has to be integrated with policies adopted at national and regional level, is influencing the majority of national strategies towards the sustainable development, being therefore their contents considered essential and a starting point for the integration of circularity into urban policies and plans.

For what concerns the context definition, it is important to assess other plans and programmes that may influence sustainability and circularity objectives in order to identify those circu-

larity issues that might influence in the preparation of the plan and identify those objectives that are reflecting circularity and sustainability.

BOX A2: An example of European and Italian relevant policies to analyse for the identification of circular trends
Italian National Strategies
- PNRR
- National Biodiversity Strategy 2011 - 2020 (SNB)
- Italian National Strategy for Sustainable Development
- National plan for adaptation to climate change
-**Regional strategies (Emilia-Romagna)**
- Regional Law 24/2017
- Regional integrated transport plan (PRIT)
- Water Protection Plan (PTA),
- Regional Energy Plan (PER, 2017)
- Regional Waste Management Plan (PRGR, 2016) and Regional Plan for Waste Management and Reclamation of Polluted Areas (PRRB, 2021-adottato)
- Regional Strategy for Climate Change Mitigation and Adaptation (SMACC)
- Regional Strategy 2030 Agenda for Sustainable Development (SRA 2030, 2021)
- Pact for climate and work (PLC)

5.3. Developing circularity objectives for the appraisal

Once both the components to assess and the strategies included in the higher-tiers policies are identified, it is possible to build a list of objectives to be used for the external coherence assessment. In fact, the objectives of the plan have to be checked in respect to a framework, whose objectives are coming from higher tiers plans and policies. In the context of the present methodology what is usually identified as SEA objectives, is transformed into a reference circularity framework for the appraisal. It consists in the identification of the objectives and target to reach per each of the components identified in the previous stage, by building upon the most important documents in force at global, EU, national and regional level. Also in this case, the outcomes really depend on the different local situations.

By analysing the strategic documents in force at global and EU level, a first draft for the appraisal is proposed in the following table , considering as components to be assessed the three city domains already previously described, i.e. the social, ecological and technological ones. Circularity objectives

are clustered according to the cities' dimensions, with specific reference to the strategy which is acknowledging it. When defined at European level, the targets have been reported in the table; in many cases, targets depend on the local context thus it is not possible to provide a general indication. In any case, also the ones defined at EU level will have to be tailored by local government.

Tab. 8. Draft of circularity framework for the appraisal. (Author's elaboration)

SOCIAL		**Target**
Simplified objectives coming from the policy documents	Reference	
S1. Equitable and inclusive high-level education that promotes equal opportunities; strengthening of the system and skills; research and technology transfer.	Agenda 2030	
S2. Striving for social inclusion and promotion, reducing inequalities and poverty.	Agenda 2030	
S3. Facilitating participation in the labour market and strengthening its active policies, ensuring decent work for all.	Agenda 2030	
S4. Make cities and human settlements inclusive, safe and sustainable and promote the city as an engine of development.	Agenda 2030	
S5. Guarantee the availability and sustainable management of services for all (e.g. water, mobility, healthcare) by enhancing them.	Agenda 2030	
S6. Ensuring health and well-being for all, reducing the population's exposure to environmental and anthropogenic risk factors and air pollution.	Agenda 2030	
ECOLOGICAL		
Simplified objectives coming from the policy documents.	Reference	
E1. Promote the regeneration of urbanized and rural territories, the recovery and redevelopment of brownfields, combat desertification and halt the degradation of the land and its balance.	Agenda 2030	
E2. Safeguarding, restoring and conserving natural ecosystems, biodiversity, species and habitats and reducing pressure on them.	Agenda 2030 - Biodiversity strategy	At least 3 billion new trees in EU by 2030.
E3. Enhance and extend natural environment through the establishment of protected areas, strengthening the understanding of the benefits of the ecosystem services through the integration of these values into plans, policies and programmes.	Biodiversity strategy	Protected areas covering at least 30% of land and sea.

E4. Guarantee and promote the sustainability of agriculture and forestry, through the dissemination of best practices for cultivation and the promotion of new innovative techniques and the sustainable management of forests with the aim of combating their abandonment and degradation.	Agenda 2030	
E5. Minimizing emissions and reducing concentrations of local pollutants and GHGs in the atmosphere.	Green Deal	- 55% of car emissions by 2030 and all-new cars with zero emissions by 2035. - 50% in van emissions by 2030 and zero emissions by 2035. - 55% greenhouse gas emissions by 2030.
E6. Increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity.	Agenda 2030	
TECHNOLOGICAL		
Simplified objectives coming from the policy documents.	Reference	
T1. Improvement of urban and building quality with reference to environmental performance, healthiness and comfort of buildings, seismic safety, right to housing.	Green Deal	
T2. Adopt urgent adaptation and mitigation measures (actions, plans and programmes) to combat climate change and its consequent impact.	Agenda 2030 - Green Deal	Achieve climate neutrality by 2050 by reducing transport emissions by 90% by 2050.
T3. Reduce the production of municipal waste per capita, in particular special and undifferentiated waste, by no longer allowing in landfills undifferentiated municipal waste or waste suitable for recycling or other types of recycling or recovery.	Circular Economy Action Plan	
T4. Increase the recycling and recovery of waste through the promotion of the market for secondary raw materials and separate collection, and include a maximum limit on the delivery of waste to landfills and specific treatment requirements.	Circular Economy Action Plan	
T5. Develop new green supply chains for the recovery of materials, reuse and recycling, with attention to the climate/energy supply chain, the industrial, food and construction chain and the residual use of waste-to-energy plants for the energy valorisation of undifferentiated municipal waste that cannot be further recycled.	Circular Economy Action Plan	
T6. Increasing energy efficiency, energy sustainability and the production of energy from renewable sources.	Agenda 2030 - Green Deal	Increasing to 40% the share of renewable energy by 2030. Improve energy efficiency by 36% by 2030.

T7. Improve the sustainability and resilience of the economic system, efficiency and the promotion of circular economy mechanisms by launching research laboratories.	Circular Economy Action Plan
T8. Building resilient infrastructure and promoting innovation and equitable, responsible and sustainable industrialization.	Agenda 2030
T9. Driving to the Third Industrial Revolution.	Green Deal

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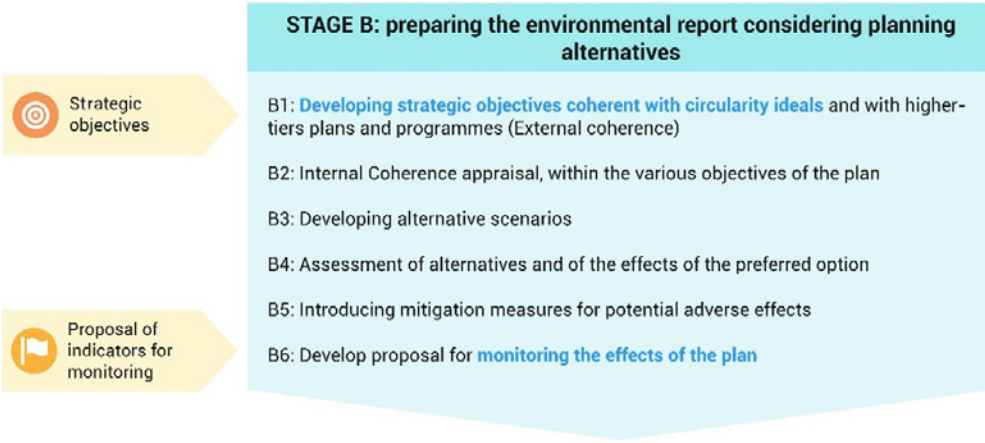
6. PREPARING THE ENVIRONMENTAL REPORT: A PROPOSAL OF PRINCIPLES AND OBJECTIVES TO EMBED CIRCULARITY AT URBAN LEVEL*

The key aspects of preparing the environmental report are the development of strategic objectives of the plan coherently with circularity ideals as well as the development of a proposal for monitoring the effects of the plan.



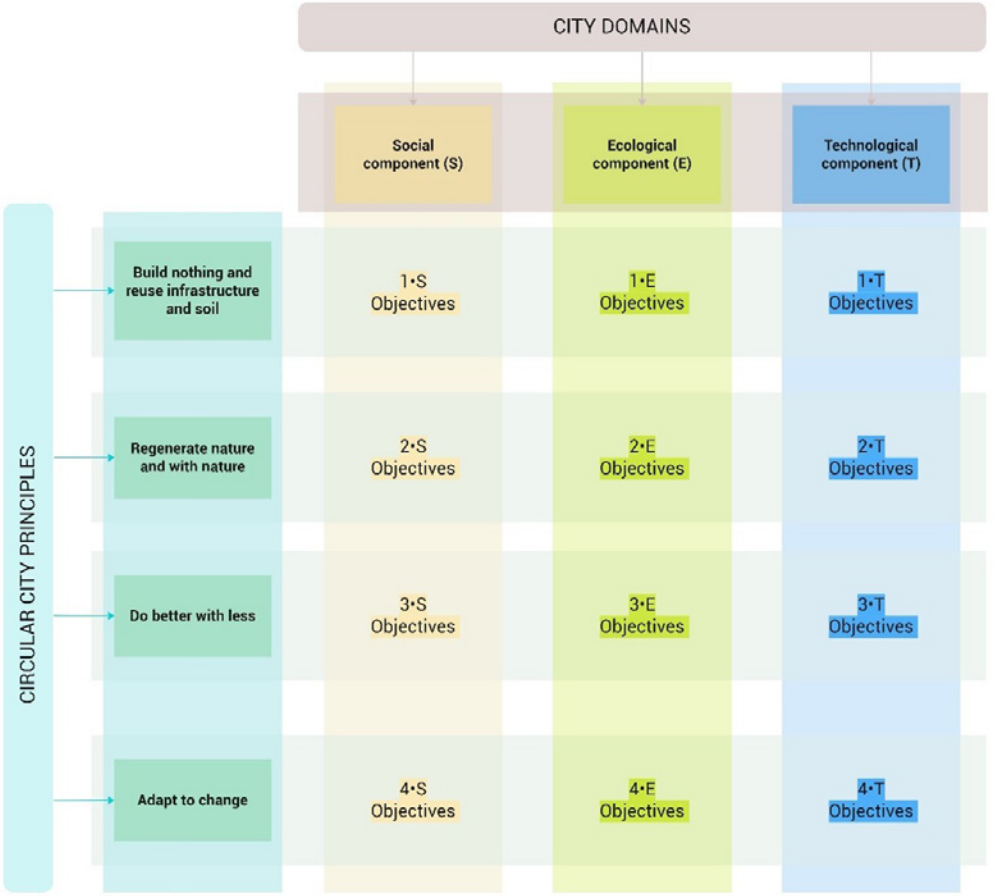
11. The proposed circular-inclusive SEA. Detailed steps for the preparation of the environmental report

6.1. Identification of circularity objectives as a guidance for policy-makers

Strategic objectives are proposed in order to effectively implement the vision at which the principles are aiming. To make the objectives easily understandable and operative for policy-makers, they are formulated according to the SETS domains and the four guiding principles (fig. 12).

Within the social domain, aspects related to social inclusion are encompassed in the formulation of the objectives, as well as the participation of local actors in the planning and co-design of the planning decisions. As for the ecological domains, besides the objectives coming from the preservation of the natural sys-

* Part of the chapter has been published in Tondelli, S. & Marzani, G. (2025). How to plan for circular cities: A new methodology to integrate the circular economy within urban policies and plans. *Sustainability*, 17, 5534. https://doi.org/10.3390/su17125534



12. Definition of objectives for each principle and for each city's domains. (Author's elaboration)

tems, the strong relation between the social and ecological domains in terms of benefits and health has been recognized and the criteria for the ecological domains are directly integrating these considerations. When it comes to technological domain, the objectives are related to a better knowledge of the existing built environment and the transition towards flexibility in its use, as well as the reduction of negative externalities in order to not harm the ecological system.

In the following, the identified objectives are specified, divided by guiding principles.

Build nothing and reuse infrastructure and soils, fostering zero-waste ideal

Tab. 9. Objectives for S-E-T domains interpreted according to the "build nothing and reuse infrastructure and soils, fostering zero-waste ideal" principle. (Author's elaboration)

1▪S Objectives	1▪E Objectives	1▪T Objectives
Increase quality and accessibility of existing public spaces and facilities. Adaptive reuse practices, including cultural heritage, through participation and pilot projects. Identification of areas for exchanging second-hand products, to host reuse initiatives (e.g. repair café).	No net land take by 2050. Promotion of land decontamination practices for brownfield regeneration to foster innovative CE projects.	Reuse of abandoned infrastructure. Adoption of a plan for disassembly at the end of life and/or conversion of existing infrastructure. Public buildings renovation and incentives for private buildings maintenance. Turn to zero waste infrastructure: energy – waste – water – synergies between buildings. Identification of areas for the temporary deposit of materials to be reused.

Regenerate nature and with nature in urban areas

Tab. 10. Objectives for S-E-T domains interpreted according to the "regenerate nature and with nature" principle. (Author's elaboration)

2▪S Objectives	2▪E Objectives	2▪T Objectives
Improve the offer of cultural ecosystem services in deprived areas. Improve the value of nature, increase accessibility to green areas and blue infrastructure contributing to health and well-being in the city.	Promote reforestation practices in urban areas to tackle air pollution and achieve carbon neutrality areas. Restore and protect biodiversity Improve the offer of regulative ecosystem services. Create synergies between green and blue infrastructure and spaces of social relations, also in relation to the ecological network outside urban areas.	Improve the diffusion of NBS for urban regeneration (e.g. green walls, green roofs, new urban green areas, new trees, Sustainable Urban Drainage systems). Promote incentives for diminishing the imperviousness of outdoor private areas.

Do better with less, reducing resources exploitation and optimizing the use of spaces

Tab. 11. Objectives for S-E-T domains interpreted according to the "Do better with less, reducing resources exploitation and optimizing the use of spaces" principle. (Author's elaboration)

3▪S Objectives	3▪E Objectives	3▪T Objectives
Promotion of co-housing and co-working spaces. Promote shared and low-carbon mobility solutions. Foster multi-actors collaboration in the use of spaces and the reuse of the same space at different hours.	Optimize the offer of provisioning ecosystem services.	Monitor the whole life-cycle of new infrastructure and urban interventions. Reduce material consumption (material input reduction) for new infrastructure through green public procurement. Reduce reliance on scarce resources. Foster the transition to renewable energy also through the creation of energy communities around public spaces. Enable and promote the smart and digital transition. Foster mixed-uses and compact city development. Foster the development of industrial symbiosis process.

Adapt to change, fostering flexibility, resilience and inclusiveness

Tab. 12. Objectives for S-E-T domains interpreted according to the "Adapt to change, fostering flexibility, resilience and inclusiveness" principle. (Author's elaboration)

4▪S Objectives	4▪E Objectives	4▪T Objectives
Temporary uses of spaces supporting pop-up initiatives for the regeneration of public spaces through flexibility and adaptive solutions. Co-design of solutions to enable adaptive and "circular" communities (participation). Fostering the adoption of cooperation agreements for urban commons.	Foster the diffusion of green areas in urban environments to manage extreme events like floods and urban heat island effect.	Availability of flexible last-mile solution through shared cars, bikes, buses, trams and trains. Foster the development of multi-functional spaces.

It is worth noting that the outcome of this process is reflecting the interpretation of the circular city paradigm that embraces together the concept of resilience, ecological regeneration and smartness, in order for the city to be sustainable and future-proof. In this respect, the author acknowledges that many of the identified objectives are not new, since they have been also associated through time to the different paradigms in order to operationalize them (e.g. compact development, mix-use, low-carbon mobility). However, the proposed framework is innovative in the fact that it includes some of the crucial aspects that are now firmly established in EU policies and directives and keep them together, thus interpreting a circular city that is resilient, adaptive, and eco-efficient. Referring to this framework, local policy-makers will plan not only for a city made of closed resource flows but also of social relations and new ways of using public spaces.

Reducing resource consumption, optimizing the existing infrastructure, aiming at the zero-waste ideal in urban transformation, fostering the role of culture and communities' engagement and adaptation in circular economy transition represent the pathway to face resource scarcity, and also tackle other key challenges of the present day, like the climate change mitigation and adaptation, thus increasing resilience towards natural hazards.

A strength of trying to embrace all these aspects, is that the proposed framework still remains valid besides the actual circular economy momentum and beyond the circular city paradigm, aiming at improving citizens' quality of life.

To offer a proposal for policy-makers, the objectives represent a first suggestion to build circular-inclusive plans. Local policy-makers can start from the adaptation of the suggested objectives, by selecting the relevant ones for the scope of the plan and the characteristic of their municipality. Being tailored for urban plans, the objectives are already targeting the scope of spatial planning discipline, however some of them could be more coherent and of primary importance depending on the local context of the plan and policies adopted at higher levels.

By following the list of objectives already provided, the external and internal coherence are guaranteed, in relation to the global and European target.

Validation of the objectives

As mentioned in Chapter 3, the key principles have been validated through an anonymous questionnaire that has been shared with policy-makers, academia and experts in the circular economy field. Also strategic objectives have been included in the survey. In particular, the objectives for each principle have been outlined and a rating system from 1 to 5 has been chosen to assess the objectives. The "I don't option" has also been included, to not force participants in giving necessarily an answer if the topic was not in their expertise. Interviewees should evaluate the proposed objectives according to the importance that they play, in their opinion, in planning a circular city. In addition to the rating system, a text box was added so to make it possible for respondents to provide some general comments and longer feedback.

The respondents had the possibility to rank from 1 to 5 the coherence and importance of the objectives with the concept of circularity, where "1" corresponded to less important or not meaningful and "5" was meaning highly important.

Also in this case, there was the possibility for participants to provide some comments or integrate some important aspects that were thought to be missing or not well focused/represented by the proposed objectives. In most of the cases, many of the received comments were anticipating some of the objectives already included within other principles coming in the following sections of the questionnaire. Given that it was not possible to provide an exhaustive overview of the principles due to the excessive length that the questionnaire would have reached, it was decided to not move the objectives from one principle to another, but simply considering those comments that were adding or modifying some of the objectives. In this case, the proposal has been added only if considered in line with circularity, relevant for the urban scale and not already indirectly included in other objectives. As an example, an interviewee proposed to add the promotion of smart working in public administration, but it has been considered as already encompassed under the objective "Enable and promote the digital transition" that, thanks to this comment has been slightly rephrased in "foster and support the digital and smart transition". Many of the comments have been taken into consideration for building a proposal of indicators (presented in

the following §6.2), especially if the feedback were referring more to specific actions rather than to a strategic objective.

As a result of the scoring procedure, the average scores have been calculated, and since all the proposed objectives got a mark higher than three, all the items have been maintained in the list. In some cases, they were rephrased or slightly modified, according to the suggestions.

The final version of the strategic objectives is the one presented above.

6.2. Monitoring

A proposal for the monitoring strategy has to be included into the environmental report, even though the monitoring of the plan starts after its adoption. A selection of indicators is fundamental in order to assess the performance of the plan. According to Floris et al. (2023), for each indicator the following information should be identified:

- The unit of measure;
- The source for the data used in the calculation;
- The baseline value;
- The benchmark, namely the target to achieve.

In the case of the present methodology, a selection of indicators is proposed. However, since as above mentioned the circularity objectives have to be tailored to the local context, only the information related to the unit of measure and the source are provided. In fact, the baseline and the benchmark strongly depend on the different contexts to which they are applied. However, what is considered useful to support policy-makers is to provide an overview of the possible ways to measure the proposed objectives.

The following indicators, divided into three tables one per each cities' domain, have been mainly formulated through the outcomes of the literature review. More than 350 indicators are proposed by academics, and some of them are the most recurrent, and have been filtered according to their spatial planning scope. Moreover, some of the indicators are also able to orient the assessment of the proposals for the implementation of the plan, being more specific and applicable also at smaller scale. In this case, the indicator is highlighted in blue.

Tab. 13. Indicators for the technological domain

	Technological domain - objectives	Indicators	Reference
Build nothing and reuse infrastructure and soils, fostering zero-waste ideal	Reuse of abandoned infrastructure	Sqm of reused buildings/sqm abandoned buildings when the plan is adopted	adapted from [1]-[2]-[3]-[7]-[10]
		Number of private retrofitted buildings	[1]-[2]-[3]-[5]-[7]-[10]
		Sqm of new buildings/sqm of abandoned buildings	
	Adoption of a plan for disassembly at end of life and/or conversion of existing public infrastructure;	Presence of the plan for public buildings and infrastructure	adapted from [2]
		% of recycled materials for the construction of new buildings	adapted from [7]
		% of reused materials for repurposing in the new buildings	adapted from [2]-[7]-[10]
	Public buildings renovation	Energy production/waste generation ratio for public buildings	[3]
		Green public procurement criteria adopted	[9]-[10]-[13]-EC monitoring
		Energy produced with renewable resources in public buildings [kWh/smq]	adapted from [7]-[12]
	Design zero-waste infrastructures		
	Energy	Energy production/waste generation ratio	[3]
		Energy consumption (kWh/ab * year)	[7]-[10]
		Electricity consumption in residential and non-residential buildings	[10]
		Share of renewable energy	[1]-[7]-[8]-[9]-[10]
		Share of renewable energy in the city heating [% on the total residential buildings]	[7]-[10]
		Energy labelling in buildings [number of labelled buildings/totals]	[5]
	Water	Water efficiency OR Dispersion from municipal water supply [%]	[1]-[10]
		Water consumption in industries [l/year]	
		Households' water use [h/day]	[7]-[10]
		Quantity of grey water reused	[4]

	Waste	landfilled waste [%]	[1]-[3]-[4]-[13]
		% waste per capita or per household	[10]-[13]
		% waste per industry	[13]
		% of recycled waste	[1]-[7]
		% of reused waste	[8]-[10]
		Generation of food waste per household	[13]
	Loop strategies	number of projects developed (with public or between private properties) to close resources cycles	adapted from [1]
		Number of companies that reuse waste	[2]
	Identification of areas for the temporary deposit of materials to be reused	Number of new temporary deposit	
Regenerate nature and with nature in urban areas	Improve the diffusion of NBS for urban regeneration (e.g green walls, green roofs, new urban green areas, new trees, Sustainable Urban Drainage systems)	Sqm of new green urban areas coming from de-sealing practices	[2]-[11]
		Sqm of green roofs and green walls	[1]-[2]
		Km of SuDS developed in the city	
Do better with less reducing resource exploitation and optimizing the use of spaces	Monitor the whole life-cycle of the new infrastructure and urban interventions	Number of infrastructure and buildings undergoes life-cycle assessment studies	Adapted from [13]
	Reduce material consumption (material input reduction) for new infrastructure	Material input - raw material demand for new infrastructure	[3]-[7]-[8]
	Reduce reliance on scarce resources	% of scarce resources substituted with other materials	Ellen MacArthur Foundation
		Number of projects adopting bio-based materials [tons/project]	Adapted from [3]

	Foster the transition to renewable energy also through the creation of energy communities around public spaces	Number of energy communities established in the city	
		Self-consumed over the total energy produced over a set period in each energy community	[11]
		Shared energy over total energy consumption of the community over a set period in each energy community	[11]
		Ratio between energy fed to the grid and energy withdrawn from the grid over a set period	[11]
		Ratio between the sum of self-consumed and shared energy over the total energy consumption of the energy community over a set period	[11]
	Enable and promote the digital transition	% of population with access to a broadband connection (>30Mb/s)	[5]
		Accessibility to smartphones	[1]
		% public spaces covered by public wi-fi	
		Use of digital tools to create community life	[5]
		Number of digital twins developed for public buildings	
		Number of smart buildings	[9]
	Fostering mixed-uses and compact city development	Density of Mix-uses	
		Volume of the built environment/sqm of public space	adapted from [5]
	Foster the constitution of Industrial Symbiosis processes	Number of IS networks	[7]
		Number of companies participating in IS networks	[7]
Adapt to change, fostering flexibility, resilience and inclusiveness	Availability of flexible last-mile solution through shared cars, bikes, buses, trams and trains	Modal share [%]	Ellen MacArthur Foundation
	Foster the development of multi-functional spaces	Sqm of multi-functional areas per capita	adapted from [4]-[5]
		Public space density: Pedestrian areas, squares, and green spaces per capita	[10]

Tab. 14. Indicators for the ecological domain

	Ecological domain - objectives	Indicators	Reference
Build nothing and reuse infrastructure and soils, fostering zero-waste ideal	Achieve the objective of no net land take by 2050	% of virgin soil sealed	
		% de-sealed soil	adapted from [4]
		Ha of areas redeveloped or recovered if abandoned	[2]-[3]-[5]
		% of virgin material extraction	[3]-[7]-[8]
	Promotion of land decontamination practices for brownfields regeneration to foster innovative CE projects	Sqm of brownfields	adapted from [4]
		Sqm of contaminated land restored/total contaminated land	
		CO2 avoided	[2]-[10]
Regenerate nature and with nature in urban areas	Promote reforestation practices in urban areas to tackle air pollution and support carbon sequestration	Number of new planted trees	adapted from [4]
	Restore and protect biodiversity	% of sites protected /total	[5]
		Consistency and threat level of vegetal and animal species	Protected areas report
	Improve the offer of regulative ecosystem services	Carbon storage and sequestration in vegetation and soil/year [g/(sqm/year)]	[3]-[4]
		Particulate matter captured by vegetation/year	Adapted from [3]-[4]
		Noise reduction	[4]
		Annual average air quality (particulate matter <10)	Adapted from [3]-[4]
		Increase in the potential water retention from SuDS [mm]	[7]
	Create synergies between green and blue infrastructure and spaces of social relations, also in relation to the ecological network outside urban areas	Accessibility of GBI	[4]
		Number of meeting places within GBI	[4]
Do better with less reducing resource exploitation and optimizing the use of spaces	Optimize the offer of provisioning ecosystem services	Sqm of land use dedicated to peri-urban and urban farming	adapted from [3]
		Fresh water supplied by ecosystem	

Adapt to change, fostering flexibility, resilience and inclusiveness	Foster the diffusion of green areas in urban environment to manage extreme events like floods and urban heat island effect	Sqm of NBS	adapted from [3]
		Investment in green infrastructure climate mitigation funding [€/year]	[5]
		Temperature reduction in urban areas [°C]	[3]-[11]
		Sqm with reduced risk in flash-flooding	[4]

Tab. 15. Indicators for the social domain

	Social domain - objectives	**Indicators**	**Reference**
Build nothing and reuse infrastructure and soils, fostering zero-waste ideal	Identification of areas for exchanging second-hand products, to host reuse initiatives (e.g. repair café)	Sqm of repair shops	adapted from [4]
		Sqm of areas dedicated to the exchange of second-hand products	
		Number of companies related to CE	[7]-[9] [13]
		Number of CE-related start-ups	[3]-[7]-[9]
	Increase quality and accessibility of existing public spaces and facilities	Proximity of population to public facilities	adapted from [3]
	Adaptive reuse practices, including of cultural heritage, through participation and pilot projects	Number of bottom-up initiatives for reuse of cultural heritage	[4]-[5]
		Number of cultural assets identified as "urban commons"/total of cultural assets [%]	[5]
Regenerate nature and with nature in urban areas	Improve the offer of cultural ecosystem services, especially in deprived areas	% of green areas with socio-cultural activities/total	adapted from [4]
		% of green areas with sports facilities/ total	adapted from [4]
		Urban Green areas quality (e.g. depending on the dimension)	
	Foster the value of nature by improving accessibility to green areas and blue infrastructure, contributing to health and wellbeing in the city	Ha green areas per 100.000 population (ISO 37120)	adapted from [2]-[3]-[11]
		Accessibility to green areas (<300 m)	adapted from [4]
		Health care spending on diseases caused by air pollution amounted on the total health expenditure [%/year]	[3]
		Attraction of investments in environmental and circular projects (willingness to pay of the public body to avoid health problems)	[3]
		Accessibility to blue infrastructures	

Do better with less reducing resource exploitation and optimizing the use of spaces	Promotion of solution for shared and low-carbon mobility	% of population using car sharing	
		% of population using bike sharing	
		% of population using public transport	[1]-[7]-[10]
		Accessibility to public transport stops	adapted from [3]
		% of private transport and typology of cars	[7]-[9]
		km of roads dedicated to public transport / tot km	[10]
		km of roads with safe sidewalks or bike lanes/ tot km	[3]
	Promotion of solution for co-housing and shared working spaces	Number of incentives for sharing private properties	
		Sqm of co-housing / population +18	
		Sqm of co-working / working population (18-65)	
		Sqm of housing / population	
		Sqm of offices /working population (18-65)	
	Foster multi-actors and multi-function collaboration in the use of spaces (e.g. reuse of the same space in different hours)	Sqm of un(der)used spaces	
		sqm shared urban land / total [%]	[5]
		% of population with access to shared and multi-functional spaces	adapted from [5]
	Temporary uses of spaces supporting pop-up initiatives for the regeneration of public spaces through flexibility and adaptive solutions	Sqm dedicated to temporary uses and/or agreements for pop-up initiatives	[4]
Adapt to change, fostering flexibility, resilience and inclusiveness	Co-design of solutions to enable adaptive and "circular" communities	New forms of cooperative economy and solidarity	[5]
		% Persons affected by climate change, cyber-attacks, pandemic disaster % (n. person affected/total population)	[7]
		% Population with middle or high education	[7]-[9]
		Number of initiatives about CE carried out with citizens' participation	
	Fostering the adoption of cooperation agreements for urban commons	Number of cooperation agreements for urban commons	

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CONCLUSIONS

To achieve sustainability and resilience in urban settlements in response to contemporary challenges such as resource scarcity and climate change, the integration of circular economy policies into spatial and urban planning represents a significant opportunity for cities to thrive. Circular economy is increasingly acknowledged as one of the most comprehensive models for achieving environmental, social, and economic sustainability. It seeks to overcome the linear economic model based on the extraction of new raw materials, the production of goods, and the generation of waste. Within a circular approach, negative externalities are retained within the system and lose their status as waste. Through the progressive abandonment of the take–make–dispose model and the adoption of a circular economy transition, material consumption is reduced, the redesign of products and materials leads to less resource-intensive outputs, and waste is reintroduced into the system as a resource for the production of new goods and materials. Scholars have expanded the original economic scope of circular economy by applying it to meso- and macro-scales such as districts, cities, and regions, recognising the benefits of this holistic and systemic transformation. As a result, the paradigm of the circular city is emerging.

The circular city concept is an evolving paradigm characterised by multiple definitions. It aims to address the aforementioned challenges while integrating key features of existing urban paradigms, including the eco-city, the resilient city, and the smart city. Alongside the plurality of definitions, cities adopt diverse motivations when engaging in the transition towards circularity, a process that is partially fostered by European policies and directives. Existing policies primarily promote the development of circular businesses and initiatives at the urban level, which contributes to a fragmented interpretation of the con-

cept. Consequently, the translation of circular economy policies into practice remains fragmented and reflects the absence of a comprehensive and holistic framework capable of supporting policy-makers in planning more circular urban areas. Furthermore, no holistic pathway currently exists to measure the progress, impacts, and opportunities of circular economy strategies implemented in cities. Policy-makers are therefore attempting to define what a circular city should look like without having effective instruments to translate theory into practice and convert knowledge into spatial transformations.

This situation highlights the urgency of integrating circular economy practices into spatial planning, given its transformative potential in creating circular systems and influencing the design and management of the built environment while encouraging circular practices. Land-use planning can allocate space for circular experimentation, promote the co-location of complementary activities and industries, and play a crucial role in protecting and enhancing ecosystem services as mechanisms for adaptation. It is therefore essential that circularity principles permeate and guide spatial planning strategies in order to enable the implementation of circular cities in a systemic and holistic manner.

The overall aim of this book is to support policy-makers in integrating circularity into urban plans through two fundamental steps. First, the study focuses on framing and systematising the existing state of the art, which is continuously evolving and reflects the conceptual ambiguity of the circular economy. Second, the research seeks to provide a clear interpretation of the circular city and a methodological framework to guide urban planners in the conceptualisation of spatial plans, drawing on the insights and lessons developed in the first part of the study.

What does circularity mean if applied to cities and according to an urban planning perspective?

By building on the literature review, the author acknowledges that the circular city concept is emerging as a new relevant paradigm that aims at addressing the challenges of resource scarcity, resilience towards climate change effects and a just digital tran-

sition. The circular city appears as a paradigm capable of bringing together and pursue the objectives of the other significant paradigms that traced the evolution of the contemporary cities so far. The circular city in particular aims at being dynamic both in terms of time and use of space in order to face citizens' needs that are evolving much more rapidly than in the past. This conceptualization of circularity in cities also reflects the fact that often circular city agendas are merged with other initiatives linked to sustainability and innovation, and some of the circular cities' aspirations are aiming for example at carbon neutrality or ecosystem regeneration. Some of these cities' initiatives are already pursuing circularity, even though not labelled under the circular city umbrella.

From the analysis of existing initiatives in European cities, the cities' tendency is to focus more on circular economy rather than on holistic circular development pathways. Despite this, some temporary experimentations happened, that have been proved to be successful by testing circularity in uncommon ways also showing the peculiar characteristic of the circular city of being flexible and dynamic in terms of time and use of space. Citizens' engagement has also been crucial for the success of the experimentations, with particular attention to foster bottom-up initiatives and co-design with local community. In this sense, culture and social inclusion can become strong drivers for the success of circularity in urban areas. In addition, also the European Urban Agenda Partnership on Circular Economy has been proved to be successful, as shown in the Municipality of Prato (Italy). In fact, the approach adopted in the partnership has been translated into local policy-making, thus influencing not only the development of the vision of the city, which is called Prato Circular City, but also urban planning tools permeating both the new structural vision of the territory 2024 and the operative plan.

When it comes to the interpretation of circularity from an urban planning perspective, a specific literature review has been conducted aiming at systematizing the existing research trends to build a solid and comprehensive state of the art. This has been a crucial starting point for answering the following research questions.

It resulted that most of the relevant publications are addressing specific sectors, like material flows and resource man-

agement, the built environment and the natural environment. Some attempts have also been made to monitor circular cities' performance, trying to give a definition of the concept through a monitoring system made of indicators. However, how to integrate the results in urban planning tools and regulations is still to be recognised.

Another trend to highlight is the importance given to stakeholders' involvement in the decision-making processes as a crucial factor for pursuing a holistic transition towards circularity in cities. However, the studies on this topic are still in their infancy, given the small number of results coming from the literature review. More efforts are needed to foster cross-sectorial collaboration, especially inside the public administrations and through an increase in citizens' participation. In fact, bottom-up and top-down processes are complementary for a vision of a future-proof city.

In terms of scale to be addressed, from the literature review it has been acknowledged that the local scale is not the most suitable one for closing the entire resources and waste flows. The role of peri-urban areas and collaborations at regional level are needed to extend the focus from urban areas towards a territorial perspective. At municipal level, it is relevant to explore how the built environment and green areas are designed, managed and used in a circular perspective, also involving citizens as enablers of the transition. In the design of new areas, the zero-waste ideal should be pursued, but is also realistic that some of the materials flows can be closed only including rural areas and by fostering cooperation with other municipalities.

What are the available instruments to integrate circularity principles into urban policies and strategies?

Most of the publications included into the scoping review are focusing on just one or few aspects of circularity, but scholars agree that holistic approaches are necessary. In an attempt of overcoming this sectorial approach and to bring together a more integrated and multi-dimensional circular thinking, the analysis has focused on some holistic frameworks that provided a vision of circularity in cities addressing the totality of sectors,

services, activities and lifestyles, as well as methodologies to foster the integration between scales and sectors. The analysed frameworks are Williams' action-based approach to circular city and ICLEI's circular city framework. What came out from the detailed analysis carried on the selected frameworks through a SWOT analysis is that, in terms of attainability, the two models are actions-oriented or proposed based on what the local governments are doing. As far as the urban domains are concerned, the top-down conceptualization of the circular cities is referring to the interpretation of the city as complex socio-ecological-technical systems. Despite the fragmentation and the many differences coming out from the analysis of the identified holistic frameworks, some commonalities have been extrapolated. Elaborating on that, a new proposal of four guiding principles has been drafted, which is better tailored to the local scale of planning rather than the existing ones and thus more efficient in supporting the elaboration of circular-inclusive urban plans.

The four principles are:

- *Build nothing and reuse infrastructure and soils fostering zero-waste ideal*
- *Regenerate nature and with nature in urban areas*
- *Do better with less, reducing resources exploitation and optimizing the use of spaces*
- *Adapt to change, fostering flexibility, resilience and inclusiveness*

How to fill the gaps to support policy-makers in planning circular cities?

A new methodology to support policy-makers in planning circular cities has been presented. In order to be effective, a system in support of policy-makers should have a clear vision of the circularity in cities, provide a guidance to orient the transformation, suggest tools and use indicators for the monitoring of the effects.

More specific objectives have been associated to the four principles, in order to offer a guidance for policy makers that aim at drafting new urban spatial plans. Aiming at creating a holistic framework thus overcoming the existing sectorial ap-

proaches, these objectives specifically refer to the cities interpreted as socio-ecological-technological system. The resulting matrix of objectives coming from the application of the four principles to the cities' domains, systematizes objectives that are not new, since they have been also associated through time to the different paradigms in order to operationalize them (e.g. compact development, mix-use, low-carbon mobility). However, the proposed methodology is innovative in the fact that it includes some of the crucial aspects that are now firmly established in EU policies and directives and keeps them together, thus interpreting a circular city that is resilient, adaptive, and eco-efficient. Referring to this framework, local policy-makers will plan not only for a city made of closed resource flows but also of social relations and new ways of using public spaces.

In terms of tools, no new instrument has been proposed in the book, but an innovative circular-based interpretation of the Strategic Environmental Assessment (SEA) has been drawn. Indeed, SEA has been already proved to be effective when applied to the local scale of planning and has been identified as a possible procedure with the potentiality to integrate diverse challenges like climate change and biodiversity loss in the assessment of plans. Moreover, it is a binding procedure to which practitioners are already used to. Thus, it has the advantages to be less time-consuming, less demanding and more easily implementable for the practitioners. The SEA is considered first and foremost as a tool in support of decision-making. In the proposed methodology, a circularity framework for the appraisal is proposed, and the internal and external coherence of the circularity objectives has been defined, supporting those policy-makers that want to embrace the circular vision proposed in the book. A proposal for a monitoring strategy is also presented. Overall, the proposal is suggesting steps and providing a first draft of contents for circular-inclusive spatial framework plans. It is a starting point for policy-makers that are requested to tailor the proposal to the local contexts, and identifying the targets for the indicators that are considered more relevant for their territories. Finally, the proposal is strengthening the need of citizens' engagement when drafting urban plans, as key stakeholders for the implementation of the circular city.

Recommendations for future research

At the end of the work, some key areas are highlighted in which further work can advance the knowledge. In fact, after the conceptualization of the circular city, the methodology consists in the integration of circularity principles into the SEA procedure but it has not been possible to test the methodology in a real case, since the SEA should be in the author's understanding the way of drafting new spatial plans. This can be the object of future work, that would lead to refine the methodology based on the results. The proposal aims at being applied in Europe, where urban planning is a competence of the local level of governance. A comparison between its application in the Italian context and other European member states can bring interesting reflection on the table. In addition, the applicability of the methodology can be tested in cities of varied sizes (like small, medium, and large) to verify if it works well or if it should be further tailored to respond to the diversity of needs (e.g. data availability for building the baseline framework). The integration of rural areas peculiarities into the reasoning can also offer new points of reflection, about the possibility of fostering a sustainable rural development pathway through circularity.

The validation of the series of principles and relative objectives through the online survey can be further expanded in terms of participants, by collecting more answers and enlarging the sample. This would allow to better refine the objectives and their formulation in order to assess if the proposed methodology can be easily adapted and replicated in other European countries.

The role of digital technology is acknowledged into the conceptualization of the circular city, but it does not appear as widely addressed in literature. Consequently, the related proposed objectives are still few. More studies can be done in terms of smart governance and smart people and how they can support urban planning towards circularity. The role of data, big data and Artificial Intelligence is also a topic for future investigation, since they represent powerful ways to assess environmental, social and economic systems in support of the definition of urban policies to foster circularity in urban areas in a sustainable way.

Finito di stampare nel mese di maggio 2026
per i tipi di Bologna University Press

Planning for Circular Cities explores how circular economy principles can be effectively integrated into urban planning and policy-making to address the pressing challenges cities face today, such as resource scarcity and climate change. The book analyses international and European policy frameworks, examines pioneering case studies such as Amsterdam and Prato, and highlights the strategic role of cities and the spatial planning discipline in advancing circular transitions. Building on literature reviews and empirical insights, it proposes an innovative methodological framework that embeds circularity into spatial planning through Strategic Environmental Assessment. The volume provides guiding principles, objectives, and indicators to support policymakers and planners in designing resilient, resource-efficient, and regenerative urban systems.

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