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Circular cities: planning for circular development in European cities

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ABSTRACT

Circular development could produce more resource efficient, ecologically regenerative and resilient cities. This development pathway offers many ecological, social and economic benefits. However, there are also many challenges to implementation, not least a heavy reliance on the market to transform urban systems of provision. A regulatory and policy framework is essential for a circular transformation, until circular activities become competitive within existing markets. Spatial and land-use planning can offer this framework. This paper provides insight into the circular development process. It discusses the role of planning in delivering circular development, using examples from four European cities. It identifies the tools for delivery and discusses the inherent limitations of using planning tools to deliver a circular transformation.

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1. Introduction

Cities are major consumers of resources (materials, energy, water and land) and producers of waste. It is important that urban resources are better managed to lessen cities' global ecological impact, increase resource security and urban resilience. Urban ecosystems are also degrading, disrupting natural cycles and damaging ecosystem services. This has a detrimental impact on the health and wellbeing of all those living in cities. Cities need to be more resilient to shocks and long-term changes, adapting to new situations, without increasing pressure on scarce resources or producing more waste. Thus, it is important that cities are resource efficient, ecologically regenerative and adaptive. This could be achieved by adopting circular development pathway.

1.1. Circular development

In recent years, there has been an explosion of circular economy (CE) literature. Some suggest that this literature is vague and lacks scientific rigour (Korhonen, Honkasalo, and Seppälä 2018). From an urban perspective, there are certainly serious shortcomings

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(Williams 2019a). The existing CE conceptualizations lack a social dimension (Prendeville, Cherim, and Bocken 2018). They fail to consider the importance of consumption (as well as production) or governance (Williams 2019a). They also fail to territorialize the CE, considering either scale or context (Williams 2019a; Bourdin, Galliano, and Gonçalves 2021). The importance of land and infrastructure has also been overlooked in the CE conceptualization (Williams 2019a).

Various authors have written about circular cities (Petit-Boix and Leipold 2018; Prendeville, Cherim, and Bocken 2018; Bolger and Doyon 2019; Paiho et al. 2020). Their focus has largely been on creating circular economies in cities; circular resource flows; or encouraging expansion of circular business in cities (Petit-Boix and Leipold 2018; Prendeville, Cherim, and Bocken 2018; Bolger and Doyon 2019; Paiho et al. 2020). They have not explored the process for creating circular urban systems, introduced here as circular development (Williams 2019a, 2020, 2021a). Circular development (CD) is a novel concept, first introduced by the author (Williams 2020) and later expanded on (Williams 2021a), which offers a new normative model for urban development. Unlike CE, its focus is on development rather than economic growth and efficiency.

CD territorializes circularity (considering both context and scale) and its impacts on urban systems, activities and infrastructure. It gives equal weight to urban systems of provision and consumption (for CE the focus is on provision). It incorporates social dimensions, recognizing the impacts of CD on society (and vice versa). It integrates political dimensions, recognizing the important role governments, industry, business and communities play in delivery. Thus, it responds to the shortcomings of CE when applied to cities.

CD is also a process that implements the infrastructure and land-use activities needed to create circular urban systems. This paper focuses on the CD process and urban planning's role in it. CD combines three processes resource looping, adaptation and ecological regeneration, to deliver circular urban systems, infrastructure and activities (Figure 1). Resource looping (reuse, recycling and recovery) is encouraged through the provision of closed-loop infrastructural systems (e.g. recyclable infrastructure, grey water recycling systems) and looping activities (e.g. conversion of organic waste to energy, biochemicals or feedstock) in cities. Urban form may alter to accommodate these new activities, enabling inhabitants to reuse and recycle resources.

CD produces adaptable systems, offering space to transform (e.g. pop-up spaces) and grow, and infrastructure (e.g. scalable, movable, refit-able, flexible) that evolves with changing needs. This is delivered via processes which support learning within communities and encourages self-organization (e.g. collaborative planning, co-provision, tactical urbanism). Urban experiments provide an opportunity to test new circular systems of provision and enables communities to quickly adapt to changing contexts.

CD also protects and enhances urban ecosystem services, which reinforce natural cycles. Ecologically regenerative actions are operationalized through the inclusion of green and blue infrastructure in the urban fabric, the management of urban ecosystems (e.g. water management, conservation, farming, forestry) and bioremediation processes (e.g. phytoremediation of contaminated urban sites).

Implementing the CD process in our cities is likely to be costly and disruptive. It will require a shift in the way we plan our cities. It will necessitate changes in social practices, lifestyles and systems of provision. This is only desirable if there are significant benefits in

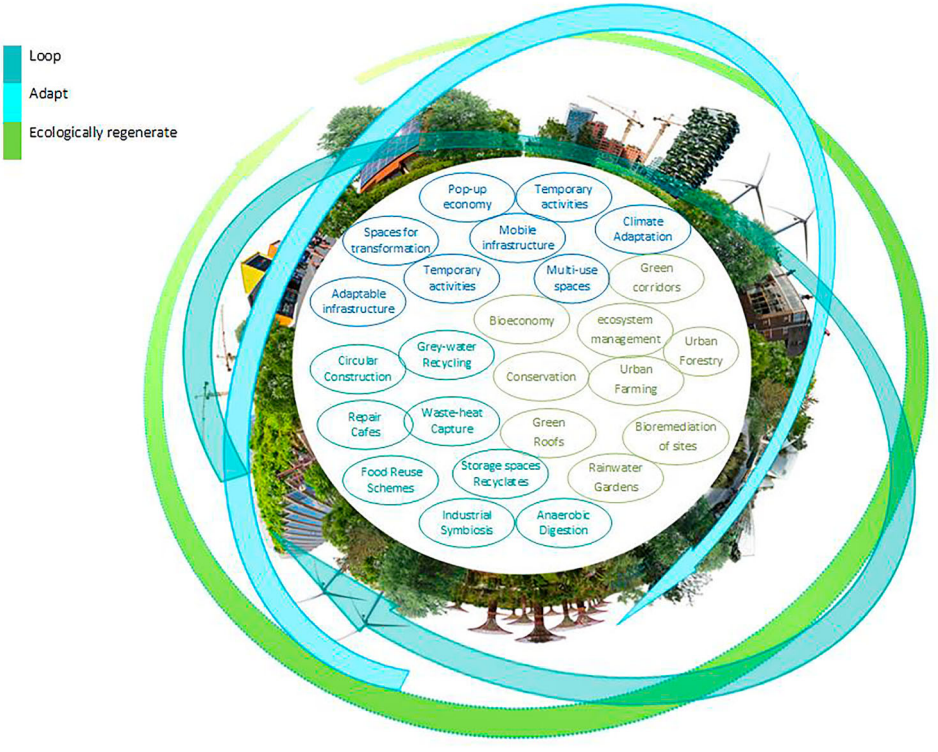

Figure 1. Circular development. Source: Williams (2021b).

doing so. Recent research showed that CD could produce many ecological, social and economic benefits (Figure 2).

1.2. Challenges to circular development

There are numerous challenges to implementing CD (Williams 2021a; Figure 3). Key challenges to the adoption of circular practices among the urban population are cultural, social and knowledge-based (Williams 2021a). However, the biggest barrier to the emergence of circular practices is the lack of circular urban systems of provision in cities. The two greatest challenges to implementing circular systems of provision are political and economic (Williams 2021a). A heavy reliance on the market to transform urban systems of provision in a neoliberal context is the key issue.

Circular activities, products and services are under-valued by the market, thus find it hard to compete with existing systems of provision (Costanza and Daly 1987; Daly 2007; Gómez-Baggethun and Barton 2013; Taheriattar 2020). There is also great resistance to transformation, due to socio-technical lock-in, institutional inertia to change and the cost of replacing existing systems (Cecere et al. 2014; Guerry et al. 2015; Williams 2019b). A lack of public investment and risk averseness within the private sector, also reduces the potential for urban transformation (Brenner and Theodore 2002; Mazzucato 2011; Williams 2019a). Overall, the lack of political and regulatory intervention in the market makes it difficult for most circular activities to compete successfully.

Figure 2. Benefits of circular development. Source: Author's own figures produced by Draught Vision Ltd.

Figure 3. Challenges to implementation. Source: Author's own figures produced by Draught Vision Ltd.

Some form of intervention is needed. A regulatory and policy framework is essential for transforming urban systems of provision, until (or unless) circular activities become competitive within existing markets. At a city-scale, spatial and land-use planning could offer the tools for delivering CD.

1.3. A potential role for urban planning

Spatial planning provides a vision and policy framework for development. Land-use planning can be used to implement that vision, offering certainty for those financing and operating new systems of provision (Steele and Ruming 2012; Peris and Bosch 2020). Strategic urban planning can be transformative, creating circular systems (Albrechts 2017). Land-use planning can influence the design of the built environment, encouraging circular practices (Bolger and Doyon 2019). In particular, land-use planning can allocate space for circular experiments and encourage the co-location of industries, to enable circular practices to emerge (Williams 2020). Land-use planning can also play a valuable role in protecting and enhancing ecosystem services (Wamsler et al. 2013; Cortinovis and Geneletti 2018) as well as providing a mechanism for adaptation (Measham et al. 2011; Rauken, Mydske, and Winsvold 2015).

Spatial and land-use planning offer a range of tools which might be used to deliver a circular transformation. Five groups of planning tools are described in the literature (Tiesdell and Allmendinger 2005; Nadin et al. 2018; Stead 2021; Table 1).

Spatial and strategic visions can enable the exploration of desirable (circular) futures (McPhearson, Iwaniec, and Bai 2016). They must also identify clear priorities, shared by key urban stakeholders (McPhearson, Iwaniec, and Bai 2016). Land-use planning (regulatory controls) can create windows of opportunity for niche innovations to emerge at the district or even city level (Williams 2016). It does this through the allocation of space for activities, the suspension of some development restrictions, or the imposition of additional environmental performance criteria (Williams 2013). The planning process also helps to build capacity among urban stakeholders to deliver new forms of development. It can build support, by creating an arena in which conflicts between niches and regimes can be negotiated among key stakeholders (Peris and Bosch 2020). However, the effectiveness of planning as a mechanism for transformation can be undermined by many factors highlighted by the literature (Table 2).

Table 1. Framework for categorizing the planning tools used to deliver circular development.

Tools	Effect	Examples
Visionary	Sets out a normative agenda or goals for a desirable future – shapes the decision environment	National planning policy, development plans, spatial visions
Strategic	Provides an integrated and long-term frame of reference for decision-making	Regional/local spatial plan
Framework setting	Contains policies, proposals and other criteria that provide a non-binding reference for other plans	Regional/local spatial plan
Capacity building	Build actor's ability to identify and/or develop more effective/desirable strategies – market capacity building	Arenas for interaction/networking Partnerships/partnering arrangements
Regulatory	Market regulating – legally binding commitments concerning land-use change and development – defines parameters of the decision environment	Planning/development controls Restrictive covenants attached to land transfers

Source: Combined frameworks from Nadin et al. (2018) and Tiesdell and Allmendinger (2005).

Table 2. Factors reducing the effectiveness of planning as a mechanism for circular transformation.

Factors reducing the effectiveness of planning	Reference
Lack of regulatory support at multiple levels	Measham et al. (2011) and Williams (2013, 2019b)
Short political cycles/ short-term policies	Bolger and Doyon (2019) and Williams (2013, 2019b)
Competing policy goals	Williams (2013, 2019b), Bolger and Doyon (2019) and Cortinovis and Geneletti (2018)
Lack of policy coherence	Williams (2013, 2019b) and Bolger and Doyon (2019)
Lack of municipal leadership	Williams (2013, 2019b) and Bolger and Doyon (2019)
Lack of municipal autonomy	Measham et al. (2011), Williams (2013) and Bolger and Doyon (2019)
Lack of municipal resources (land, funds, expertise)	Bolger and Doyon (2019), Measham et al. (2011) and Williams (2013)
Lack of municipal ownership of infrastructure and services	Williams (2013) and Bolger and Doyon (2019)
Time constraints of planning process	Measham et al. (2011) and Williams (2013)
Lack of information for decision-making	Measham et al. (2011), Cortinovis and Geneletti (2018) and Williams (2019b)
Socio-technical lock-in to existing systems of provision	Williams (2013, 2019b)
Lack of mechanisms for coordination of many actors	Williams (2013)
Difficulties engaging stakeholders	Williams (2013)
Lack of certainty for investors	Williams (2013, 2019b)
Vested interests in status quo	Williams (2013, 2019b)
Existing social practices	Bolger and Doyon (2019)

Source: Compiled using Bolger and Doyon (2019), Cortinovis and Geneletti (2018), Measham et al. (2011) and Williams (2013, 2019b).

The research seeks to determine the role of planning in the CD process. It answers two questions:

1. What planning tools are used to implement circular development?
2. What are the limitations of planning as a tool for implementing circular development?

1.4. The research contribution

The novelty of this research stems from the concept of CD and trying to illustrate the achievements and problems faced by urban planning in delivering it. The holistic nature of the concept of CD makes an important contribution to the existing literature. It provides an original articulation between the social, economic and political dimensions of the CE associated with CD and promoted by urban planning. The capacity of urban planning to foster the development of circular cities has also been little studied. My previous work (Williams 2020, 2021a) touched upon planning as one of several tools for implementing CD. But this research provides a more systematic, detailed, comparative analysis of how planning has actually shaped CD in different contexts. Thus, it provides a richer understanding of this important process, making a valuable contribution to existing literature.

2. Methods

A qualitative, mixed-methods approach was used to explore these questions. Deductive content analysis of both secondary and primary (26 key stakeholder interviews) data

sources was completed, for four comparative case studies: Amsterdam, Paris, London and Stockholm. These cities were chosen because they provided a representative sample of a range of CD pathways currently emerging in Europe.

Amsterdam has adopted a strategic, city-regional approach to resource looping, of construction and organic waste. Land has been designated for waste and bio-clusters to encourage industrial symbiosis in the port area. The development of bio-refineries has enabled organic materials to be recycled or energy to be recovered locally and at a scale. In addition, nutrients are recovered from residual food for reuse (by restaurants or foodbanks) or composting. Space has also been designated in the city for resource banks to facilitate the circular construction process. Public procurement (of recycled building materials), circular tendering and land release have generated demand for construction recyclates.

Amsterdam is encouraging the emergence of neighbourhood-scale, pop-up circular experiments in the ex-industrial district of Buiksloterham. Here vacant, often contaminated, municipally owned sites, are being made available temporarily for circular experiments. De Ceuvel is one such experiment, constructed on a contaminated site, it offers an excellent example of CD. Phyto-remediating plants have been used to decontaminate the soil on site. Off-grid, above surface infrastructure has been integrated into the development, to avoid subsurface infrastructure from being buried in contaminated land. Dry composting toilets and separated urine collectors are used to produce fertilizer for local food crops. Helophytic filtration systems enable on-site, grey water recycling, while waste-heat from the accommodation is captured and reused. Houseboats have been adaptively reused for workshops, offices and a café. Thus, the site is ecologically regenerated, resources are looped and a temporary home for businesses adopting the CD model is provided.

Paris has also adopted a city-regional approach to looping construction materials, food and water.

Paris aims to create a local circular food system through the reuse of food waste and the regional production of food, both in the city and in surrounding districts. This is supported by the *Parisculteurs* initiative, which aims to cover the city's roofs and walls with 100 hectares of vegetation by 2020. One-third of this space will be dedicated to urban farming. Food reuse is also legally enforced nationally. In Paris, food 'waste' is redistributed through cafes, food banks, community fridges. Any food which cannot be reused in the city is converted into biogas and supplements the local energy supply. Paris also coordinates the strategic, adaptive reuse of sites and buildings through initiatives such as *Paris Reinvented*. Temporary planning permissions, space brokers and online marketplaces help to facilitate the process, which has precipitated many pop-up activities in the capital, which are also integral to circular systems. Paris is attempting to re-industrialize the city-region. This might enable circular industrial systems to emerge locally, increasing resource sufficiency and reducing greenhouse gas emissions from the transport of goods and materials. Networks for industrial symbiosis are more likely to form where industry is present and clustered, but space must be allocated. Paris has an eco-district – Clichy Batignolles – which also adopts CD principles. It has been designed to be climate adapted, as it integrates green infrastructure throughout the site (parks, green roofs, etc.). It also recovers heat from several processes, captures rainwater (to reduce pressure on wastewater recycling) and recycles grey water.

London provides examples of CD manifesting in major new projects and existing neighbourhoods. The Queen Elizabeth Olympic Park (QEOP) is a new eco-district, which was built for the 2012 London Olympics. It combines three circular actions. Bioremediation, local clean-up programmes and conservation schemes have helped to ecologically regenerate this previously industrial area. Diverse, natural species have been planted across the park. Waterways have been improved, while sustainable urban drainage systems have been fully integrated into the public realm. Circular construction systems (e.g. soil-washing, materials exchange platforms, resource banks) and adaptive infrastructure integrated into the Olympic development have limited material waste from the site. Brixton provides an example of tactical circular urbanism in an existing neighbourhood. It is a *transition town* with twin aims to tackle climate change and resource consumption. A series of sustainable community-led schemes, integral to CD, have emerged in the neighbourhood on recycled sites and buildings. Local food reuse (e.g. Brixton Café) and urban farming schemes (e.g. Loughborough Junction Farm) have established helping to reinforce a local circular food system. The Remakery provides a space in which the community can learn to repair or recycle unwanted or broken goods and materials. Pop Brixton provides employment opportunities for local people in the pop-up economy in recycled containers.

In Stockholm, circular thinking has been embedded into development decisions for 25 years. Circular principles first manifested in Stockholm (as Ecocycles I.0) in Hammarby. The district developed the infrastructure required to create a closed-loop, waste-to-energy system. It utilizes the existing city-wide infrastructural systems (district heating system, CHP plant and thermal power station) together with new technologies for converting sludge into fertilizer and biogas. The heat produced from wastewater purification is used by the thermal power station. Biogas is used for cooking and to power the public transport system. Refuse is burnt to provide heating for homes and businesses. Thus, sewage, waste-heat and refuse are used to produce energy. More recently, CD has manifested in Stockholm Royal Seaport. Here, Ecocycles was expanded to encompass resource cycles from both the living and port environments. For example, organic waste from ships was also used to feed the waste-to-energy system and produce compost. Ecocycles was adapted to include a grey water reuse system, which limits flash-flooding and the release of wastewater into the harbour. The stored water is reused in the port. The site has been ecologically regenerated through bioremediation and adapted for climate change.

The first stage of the analysis sought to determine which planning tools were used to implement CD in each city. The grey literature produced by the cities, expert consultants and service providers were analysed to identify those which related to CD. The coding framework (in Table 3) was used to identify relevant documents. Over 100 publications were analysed from the period 2000–2020 including: spatial plans, CE plans, environment strategies, climate action plans and climate resilience plans. Full-text reads were completed. These were analysed using the planning tools coding framework (Table 1). The findings from this deductive content analysis were then triangulated through interviews, with strategic planners from each of the cities. Interviewees were asked to indicate the planning tools used to implement CD. The same coding framework was used to analyse responses. A list of planning tools for implementing CD emerged.

Table 3. Circular development coding framework.

Circular Action (categories)	Codes	Subcodes
Loop	Reuse	Adaptive reuse, refurbishment, repair, food reuse
	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 infrastructure, blue infrastructure
	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
	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

Source: Author's own.

Table 4. Key stakeholder interviews.

Type	Number stakeholders interviewed	London	Stockholm	Amsterdam	Paris
Developer	4	X	X	X	
Construction manager	2	X		X	
Engineering/planning consultant	3	X	X	X	
Water and waste water engineer	3	X		X	X
Temporary use consultant	2	X			X
Strategic planner	8	X	X	X	X
Economic development officer	2	X		X	
Social enterprises	2	X			X
	26	8	6	6	4

Source: Author's own.

The second stage of the analysis sought to determine the limitations of planning as a tool for implementing CD in each city. A range of representative stakeholders were interviewed across the private, public and community sectors. They had all been involved in the implementation of CD (Table 4). There were 26, one-to-one, key stakeholder interviews which took place during the period June 2017–June 2019. The interviews lasted between 40 and 60 min.

The interviewees were asked both closed and open-ended questions to determine the limitations of planning for delivering CD. The interview responses were then coded using the limitations framework derived from the literature (Table 2). The outliers (new limitation categories) were noted.

3. Planning tools for circular development (results and discussion)

The analysis suggested spatial and land-use planning did play a significant role in the CD process. The case studies indicated three types of planning tools were used (corresponding to the typology in Table 1). The tools, where they were used and how they assisted in the delivery of CD are summarized in Table 5. Some examples derived from the case studies are outlined below.

Table 5. Planning tools for delivering circular development.

Tool		How the tools assist in the delivery of circular development	London	Paris	Amsterdam	Stockholm
Strategies/ visions	Spatial plan		X	X	X	X
		Identifies space for circular activities	X	X	X	
		Encourages the integration of circular infrastructure into new and existing development	X	X		X
		Encourages adaptive reuse of space	X	X	X	
		Ensures future development supports circular activities, infrastructure and systems				X
		Creates strategies to encourage regional resource looping	X	X	X	
		Co-location symbiotic activities		X	X	
Capacity building	Collaborative planning/co-design process		X	X	X	X
		Engages urban stakeholders and increases support for circular systems	X	X	X	X
		Produces appropriate circular socio-technical systems			X	
		Encourages circular practices to emerge.			X	
		Builds expertise and supply chains supporting circular systems	X			X
Regulatory	Planning conditions and land release (circular tendering and land issue; environmental performance programmes)		X	X	X	X
		Creates circular development experiments	X	X	X	X
		Engages urban stakeholders and increases support for circular systems	X	X	X	X
		Produces appropriate circular socio-technical systems			X	X
		Encourages circular practices to emerge			X	
		Builds expertise and supply chains supporting circular systems	X	X	X	X

(*Continued*)

Table 5. Continued.

Tool	How the tools assist in the delivery of circular development	London	Paris	Amsterdam	Stockholm
Temporary permissions		X	X	X	
	Provides space to adapt to new demands placed on cities	X	X		
	Provides opportunities for circular experiments in cities	X	X	X	
	Creates a demand for circular products, services and infrastructure	X	X	X	

Source: Author's own.

3.1. Strategies/visions

The four spatial plans provided frameworks to support circular systems, activities and infrastructure (green, blue, adaptive) integral to CD. The spatial plans for London, Paris and Stockholm provided a vision for CD, prioritizing circular goals which were clearly articulated (and essential according to McPhearson, Iwaniec, and Bai (2016)). Stockholm's plan (Stockholm County Council 2015) encouraged urban form (high density, mixed-use development linked by public transport and district heating networks) which supported the successful operation and expansion of a circular system (ecocycles) across the city.

The London Plan (Greater London Authority 2020) allocated land for a variety of 'low value' circular activities (e.g. urban farming, storage and logistics facilities, waste management and green space). It supported the provision of sustainable infrastructure (e.g. heat networks, renewable energy, grey water recycling and rainwater harvesting), green infrastructure (e.g. green roofs, pocket parks) and adaptable infrastructure (e.g. within strategic developments like the Olympic site) central to the delivery of circular urban systems. It also encouraged circular activities. For example, it required circular construction processes that were adopted for all strategic sites in London. It encouraged boroughs to support opportunities to use vacant buildings and land for flexible and temporary uses, which enabled adaptive reuse of space and increased the resilience of urban systems.

The Paris spatial plan (Regional Authority of Greater Paris 2013) supported blue-green infrastructure for grey water recycling, ecological regeneration and climate adaptation integral to CD (an important role according to Cortinovis and Geneletti (2018)). It also allocated space for activities integral to urban circular systems and encouraged the clustering of these activities within the city-region, to close resource loops locally (supported by Bolger and Doyon (2019)). For example, it protected farmland within the city-region; provided space for community composting and biogas plants for the conversion of food waste, thus creating local circular food systems. The spatial plan also aimed to create local industrial material loops by re-industrializing the city-region (Marie de Paris 2017). Île-de-France has a vast network of companies in key areas for the CE, including mature recycling schemes (for metals, paper) and developmental actors in the chemicals, energy and design industries.

Amsterdam's spatial plan (Amsterdam Metropolitan Region 2016) focussed on other strategic priorities (providing jobs and housing for a growing population). However, it supported the creation of waste/bio-clusters in the port, enabling local looping actions. This was supported with financial incentives through the Circular Innovation Programme (Municipal Council of Amsterdam 2016a, 2016b). The spatial plan also encouraged the use of residual heat and the conservation of green wedges in the city (all important for CD). These actions and the creation of a CE in Amsterdam were supported by the Sustainability Strategy and the Circular Vision and Roadmap, which contain CD goals (Municipal Council of Amsterdam 2015a, 2015b) implemented through the *Learning by Doing* programme (Municipal Council of Amsterdam 2015a, 2015b).

Thus, the spatial plan can be used to prioritize CD (e.g. London, Paris); or reinforce the expansion of circular urban systems (e.g. Stockholm). It can also be used to define a space in which cooperation can emerge between proximate actors, enabling local circular systems and activities to develop (e.g. Amsterdam, Paris).

3.2. Capacity building

A collaborative planning process can build the capacity (expertise, skills and supply chains) among infrastructure and service providers to deliver circular systems of provision in cities (supported by Peris and Bosch (2020)). The collaborative planning process adopted in Hammarby, allowed construction companies and service providers (water, waste, energy and transport) to design an integrated, closed-loop waste-to-energy system (A communication with a strategic planner at Stockholm City Council responsible for Hammarby Sjostad and Stockholm Royal Seaport, and a strategic planner for Stockholm Region, Sweden, 2017 (Interviewer Jo Williams, Bartlett School of Planning, University College London, London UK). The process enabled key actors to align their goals, creating reciprocal relationships essential for circular systems. Together they also built their expertise and supply chains to deliver *ecocycles*.

The collaborative process used design competitions, learning workshops, direct access to the local planners and regular multi-stakeholder workshops to promote innovation (A communication with a strategic planner at Stockholm City Council responsible for Hammarby Sjostad and Stockholm Royal Seaport, and a strategic planner for Stockholm Region, Sweden, 2017 (Interviewer Jo Williams, Bartlett School of Planning, University College London, London UK). The knowledge created through this process was applied and adapted for the Royal Seaport, by many of the same actors. The lesson learnt from these experiments transformed the local development regime (A communication with a strategic planner at Stockholm City Council responsible for Hammarby Sjostad and Stockholm Royal Seaport, and a strategic planner for Stockholm Region, Sweden, 2017 (Interviewer Jo Williams, Bartlett School of Planning, University College London, London UK). However, a lack of user-engagement in the process adopted for Hammarby, resulted in lower performance outcomes than predicted (Brick 2008; Pandis, Johanssen, and Brandt 2013; A communication with a strategic planner at Stockholm City Council responsible for Hammarby Sjostad and Stockholm Royal Seaport, and a strategic planner for Stockholm Region, Sweden, 2017 (Interviewer Jo Williams, Bartlett School of Planning, University College London, London UK).

The collaboration of the community in the development of circular projects can ensure that new systems are appropriate, which generates community support for circular systems of provision. In De Ceuvel, a co-design process, which included systems providers and user groups, was adopted. It produced a range of circular solutions. These new systems of provision met user-preferences and practical requirements (Metabolic 2013). User participation, helped to raise awareness of the possible circular flows and design solutions for the neighbourhood. Inhabitants developed the knowledge to understand how best to utilize circular systems and adopt circular practices. Project appropriation by inhabitants was the basis for success (Pistoni and Bonin 2017). This led to a virtuous loop of good practice in terms of resource management (Pistoni and Bonin 2017).

Thus, a collaborative planning process can be a powerful tool for transformation, in changing attitudes, practices and potentially lifestyles of user groups, alongside new systems of provision. Equally, it can alter the practices among system providers enabling circular systems of provision to be implemented.

3.3. Regulation

Regulatory planning tools also play a role in delivering CD (supported by Williams (2013, 2016) and Peris and Bosch (2020)). Circular tendering and land issue is a tool used for urban transformation, infrastructure renovation and demolition in Amsterdam (Municipal Council of Amsterdam 2016a, 2016b, 2017). It applies circular criteria to the release of public land or buildings for development. It has been successfully applied to four development tenders for public land (Municipal Council of Amsterdam 2016a, 2016b, 2017). The first was completed in Zuidas for a large project (250 homes and offices). This included the use of material passports and dry connection practices to enable future reuse and recycling of built structures. Secondary (recycled) materials were also used in the construction for insulation and partition walls (Municipal Council of Amsterdam 2016a, 2016b, 2017).

CD goals were formulated early in the tendering process. Responsibilities for delivery were clearly allocated (City of Amsterdam, Circle Economy and Copper8 2017). Choosing between circular goals lengthened the planning process. Understanding which construction practices and materials enabled circular demolition and disassembly was important (City of Amsterdam, Circle Economy and Copper8 2017). Prescribing functional tender criteria (such as adaptability and modularity) helped to prevent a future decrease in the value of infrastructure. Demolition and disassembly plans in tenders for construction projects ensured that the lifecycle of the infrastructure was considered from the start of a project. This all required planners had adequate knowledge to advise developers effectively (City of Amsterdam, Circle Economy and Copper8 2017).

In Buiksloterham (Port of Amsterdam), the *Manifest Circulaire* (circular tendering) encouraged development which closed energy, water and nutrient flows and enabled a transition to a bio-based economy, through the reuse of biological waste streams (Metabolic 2014). It sought to increase biodiversity and introduce climate adaptation measures. Many circular projects emerged in the area thanks to the prioritization of circular goals in the *Manifest* and relaxation of standard planning requirements (Dembski 2013; Rauws and De Roo 2016; Metabolic & SGS 2017).

Table 6. Environmental performance programmes.

	Description	Conditions targets, specifications relevant to circular development
Stockholm Royal Seaport (Stockholm)	236 hectares contaminated brownfield site 12,000 homes/ 30,000 jobs	• Fossil fuel-free by 2030 • Zero-waste to landfill • Integration of ecocycles • Climate adapted to rising temperatures, sea/groundwater levels and increased precipitation • Optimal planting regimes for: regulating ecosystem services; storm-water management; biodiversity and recreational purpose.
Queen Elizabeth Olympic Park (London)	226 hectares contaminated brownfield site 24,000 homes/ 40,000 jobs	• All new homes code-level 4 and LLDC-led developments zero carbon. • 15% reduction in embodied carbon in new construction. • 100% homes have smart meters. • Educational programmes to reduce household emissions by 15% over 5 years. • Reuse/recycle 90% of demolition and construction waste. • 25% recycled content of aggregate in new buildings. • 20% of construction materials from reclaimed or recycled source. • Materials should be locally resourced. • Promote on-site compost facilities and provide storage space for recyclables in new development. • Temporary buildings made for reuse elsewhere. • Install rainwater harvesting and grey water recycling in new developments. • Incorporate SUDS into the public realm. • Public areas to contribute to biodiversity action plan. • Design buildings with public space to reduce heat island effect.
Clichy Batignolles (Paris)	54 ha contaminated brownfield site 7500 homes/1200 jobs	• Reduce storm-water discharges by 50% into the network. • Space and water heating from 85% renewable energy sources. • Use recyclable or recycled materials in construction. • 30% of construction waste recovered or recycled. • A 10-hectare park and 16,000 m^2 of green roofs increase biodiversity help with climate adaptation and reduce runoff. 30% of the rooftop surface covered with plants. • Rainwater used for 40% of the park's watering needs.

Source: Author's own compiled from Marie de Paris (2015) and City of Stockholm (2015); London Legacy.

Amsterdam has adopted a city-wide policy for circular tendering. It aims to contribute to the development of a national standard for circular building. Already new networks for knowledge transfer to enable the development of circular construction practices have emerged. For example, a concrete network advocates the use of granulated, recycled concrete in new infrastructure. Living labs (e.g. FabCity, AMS and AUAS LivingLab) also help to demonstrate circular construction methods (Dembski 2013; Rauws and De Roo 2016; Metabolic & SGS 2017).

A second regulatory tool, the environmental performance programme (EPP), has been used to encourage CD in the remaining three cities. Conditions are placed on new projects on large, publicly owned sites which incorporate activities, processes and infrastructure integral to CD. Table 6 indicates the relevant conditions placed on new developments in London, Paris and Stockholm. The conditions can affect design (e.g. the requirement for adaptable design in the Olympic Park or the use of the green index in the Royal Seaport), materials (e.g. use of local and recycled material in construction for the Olympic Park), infrastructure (e.g. the requirement to install rainwater harvesting and grey water recycling infrastructure the Olympic Park and Clichy Batignolles), the development process (e.g. the adoption of circular construction in Clichy Batignolles and Olympic park) and lifestyles of those living in the development (e.g. the household

emission reduction programme in the Olympic Park). These programmes were implemented through contractual agreements.

A third tool – temporary planning permissions – can be used to intervene in markets, enabling circular activities to compete with commercial activities in cities. These are particularly useful in space scarce environments. Temporary permissions also increase the adaptiveness of the urban system to major changes in the landscape (e.g. economic crises, pandemics), offering opportunities to innovate and build capacity among key stakeholders to deliver new systems of provision.

Temporary planning permissions have been used as a mechanism for implementing CD in London, Paris and Amsterdam (London Legacy Development Corporation 2014; Patti and Polyak 2015; Pilsudski and Koh 2019). In Paris, they have been used to enable circular experiments, for example: food reuse cafés, the adaptive reuse of buildings and urban agriculture. This process has been institutionalized by the municipality, through the Parisculteurs and Paris Reinvented initiatives (Pilsudski and Koh 2019; Parisculteurs website 2020). Some experiments have proved so popular, that when permissions have expired they moved to new sites (e.g. Les Grand Voisins, Paris).

In London, the spatial plan (GLA 2020) encourages boroughs to support opportunities to use vacant buildings and sites for temporary uses (e.g. for food growing). Adaptable, moveable infrastructure has also been placed on sites with temporary permissions. For example, the Place Ladywell project provides mobile, self-contained pods to accommodate the homeless on sites with temporary permissions (LWARB 2017). These are inevitably replaced by commercial forms of development, but can move to other vacant spaces. In Brixton, there is a cluster of circular experiments accommodated on sites with temporary permissions. In Lambeth, this tactical approach to delivering CD has proved beneficial to the land owner, developer and community (A communication with an Economic Advisor in the Economic Development Team, London Borough of Lambeth, London, UK, 2019 (Interviewer Jo Williams, Bartlett School of Planning, University College London, London UK). It has increased the value of sites and surrounding areas, beneficial to land owners and developers. It has provided opportunities for the local community and supported the economic regeneration process.

Temporary planning permission can enable the relaxation of other planning regulations which would otherwise prevent CD. For example, De Ceuvel was built on a heavily contaminated site. The municipality temporarily relaxed the planning controls requiring soil remediation pre-construction (Metabolic 2014). Service infrastructure was built above ground and off-grid while phyto-remediating plants were used to decontaminate the soil (Pistoni and Bonin 2017). This enabled cost-effective, circular solution to the decontamination of brownfield sites to emerge. Thus, temporary permissions can produce innovation.

In the absence of demand for circular development, regulatory tools can intervene in markets and require circular development practices are adopted.

4. Key limitations of planning as a tool for implementing circular development

The key limitations of planning as a transformative tool for delivering CD, derived from the key stakeholder interviews, can be found in Table 7. Those highlighted in grey are

additional to those identified by the literature (see limitations framework, Table 2). The interviews confirmed that the role of planning in CD is limited by a lack of new construction in European cities. For all four case studies, space is scarce and urban renewal is a slow and expensive process. This makes it difficult to scale-up new circular systems of provision. Nevertheless, in all four cities, new development projects did integrate CD principles. Mostly these have not as yet transformed the development regime.

Planning provides the arena in which innovative forms of development can emerge. However, a lack of a multi-level, coherent regulatory framework supporting CD prevents those experiments transforming the development regime (Measham et al. 2011; Williams 2019b). For example, at a regional level, the London plan required that all strategic sites adopt circular construction principles. However, for smaller projects, the imposition of these requirement was discretionary for the local planning authorities, many of whom had other priorities. Equally, a lack of national regulation requiring the use of recycled construction materials in new developments, prevented circular construction practices from scaling-up across the UK. Compare this with situation in Amsterdam, where circular experiments will eventually inform national policy and transform the development regime.

The spatial plan can also provide a vision for CD presenting a large number of often competing policy goals (Cortinovis and Geneletti 2018; Bolger and Doyon 2019; Williams 2019b). However, CD is rarely prioritized and sometimes conflicts with other goals. All four cities demonstrated a conflict between the goals to densify, provide more housing and essential services and those for enabling circular activities. For example, London planners prioritized commercial and residential development over industrial uses, which created a significant barrier to closing resource loops locally, through industrial clustering. The lack of strategic prioritization of CD in spatial plans prevents systemic transformation.

Conversely, where the regulatory framework reinforces the prioritization of circular goals in the spatial plan, circular transformations are more likely. For example, in Paris, a regulatory amendment which prioritized resource conservation and environmental quality reinforced the CD goals in the spatial plan. This produced an extensive network of waste drop-off sites linked with recycling centres. It also strengthened the quality standards governing green infrastructure, which improved rainwater recycling and encouraged the inclusion of renewable energy systems in new development.

Conflicts between planning regulations and CD goals may also limit planning's role. For example, standards for soil decontamination (imposed by planning) prior to the occupation of a brownfield site may prevent its reuse. Yet, the relaxation of those planning standards might enable a circular solution (bioremediation) to be adopted to allow the immediate reuse of the site. De Ceuvel highlights the importance of such a regulatory alignment.

Spatial plans can also produce socio-technical lock-ins (Williams 2013, 2019b). Stockholm's spatial plan supported the expansion of ecocycles across the city, but it also created a lock-in. This prevented its replacement with more sustainable, circular alternatives based on renewable energy, recycling and reuse. Thus, planners suggested that visioning for spatial plans should scan longer time-horizons, to extend the relevance of the plan and avoid lock-ins in the short term. However, this would require planners had the expertise for horizon-scanning. Alternatively, performance-based policy goals

Table 7. Factors reducing the effectiveness of planning in circular transformations identified by interviews.

Factors reducing the effectiveness of planning in circular transformations	London	Stockholm	Amsterdam	Paris	Total no. interviews mentioning limitation	Type of interviewees who mentioned limitation
Lack of regulatory support at multiple levels	3				3	Strategic planner, developer, construction manager
Short political cycles/ short-term policies	4	1			5	Strategic planners, politician, economic development officer, engineering consultant
Competing policy goals	3	1	2	1	7	Strategic planners, developers, engineering consultant
Lack of policy coherence	3	1	2	1	7	Strategic planners, developers, engineering consultant
Lack of municipal resources (land, funds, expertise)	3				3	Strategic planners, politicians, economic development officer, sustainable development officer, circular economy officer
Municipal ownership of infrastructure and services	3	3		1	7	Strategic planners, sustainable development officer, circular economy officer, water and waste water engineers
Time constraints of the planning process	2	2	2	1	7	Strategic planners, developers, construction manager
Lack of information for decision-making	2	1	3	2	8	Strategic planners, developers
Socio-technical lock-in to existing systems of provision	1	2	1	1	5	Strategic planner, Engineering/planning consultant, water and waste water engineers
Limited by lack of new development	3	1	2	1	7	Strategic planners, engineering consultant, developers
Temporary permissions don't disrupt development regime	3				3	Economic development officer, temporary use consultant, social enterprise
Limited by who is engaged in capacity building	2	2	2		6	Strategic planners, social enterprises
Existing planning regulations prevent circular development			1		1	Strategic planner
Lack of enforcement		2			2	Strategic planners

Source: author's own compiled from interview results.

and the adoption of more agile and adaptable systems of provision in the spatial plan could help to avoid lock-in.

Although spatial plans may last for 10 years, political priorities change more frequently. This reduces certainty for investors and willingness to support untested circular systems. Yet, their investment is essential for a circular transformation. Also urban systems transform slowly. Thus, political priorities must remain consistent over longer

periods, in order for circular systems of provision to emerge (Bolger and Doyon 2019; Williams 2019b). In Sweden, political support for closed-loop systems was institutionally embedded in local government in 1995. The first development of the full system was completed in 2005. However, it took 50 years for the entire socio-technical systems under-pinning ecocycles to emerge.

Inconsistent policy can also impact on the broader regulatory framework (i.e. building codes, subsidies, etc.) guiding development, and undermine circular transformations (Bolger and Doyon 2019; Williams 2019b). The example given by London planners was the zero carbon homes escalator introduced in 2007. Although this is not explicitly a form of CD, it provides an indication of how political changeability can influence regulation and hinder innovation. The abolition of the mandatory zero carbon target for new homes in 2015, resulted in the removal of other instruments designed to support decarbonization (e.g. the feed-in tariff, green deal). Consistent national policies and instruments are needed if spatial plans are to successfully deliver circular transformations.

Planning can be used to intervene in markets. Temporary planning permissions provide an opportunity for circular experiments to emerge and be tested in cities. However, in practice, the experiments (unless commercially successful) are unlikely to disrupt the development regime in the short term. For example, in Brixton circular experiments engaged community groups, increased awareness and encouraged circular practices to develop locally. However, the experiments were eventually out-competed and replaced by commercial alternatives. Thus, new systems, practices and associated learning were lost. This severely limits the capacity for planning to alter markets.

A lack of local autonomy in cities, through reduced competencies and resources, can also make it difficult for planning to deliver new circular systems (Measham et al. 2011; Williams 2013; Bolger and Doyon 2019). Municipal resources (land, funds, expertise) and powers of provision offer leverage for implementing CD. For example, in Paris, the municipality operates the water system which provides leverage for the adoption of grey water and black water recycling systems. Compare this to QEOP where a black water recycling system was discontinued by the private sector provider, because the circular model was not profitable. In London, planners highlight a lack of funds and limited control over infrastructural provision as a key challenge to CD. Conversely, planners in Stockholm suggest that municipal control over utilities (waste, water, energy) and transport provision was key to the implementation of ecocycles.

The planning process can also play a role in circular transformations. However, it is constrained by time, resources and the expertise of technocrats and user groups engaged in the process (Measham et al. 2011; Williams 2013). It is also time-constrained, yet imposing CD goals will lengthen the process (demonstrated by circular tendering in Amsterdam). This has cost implications for developers, construction firms and planning authorities. It necessitates building capacity among key actors to determine the best CD options (highlighted in De Ceuvel). The interviews suggested that planners would require training and data (pertaining to ecosystem services, resource flows and stocks, costs of adaptation) to make informed choices and guide developers. Infrastructure and service providers would also require clear guidance. Enforcement is also critical. Stockholm planners found that a lack of enforcement post-construction, reduced the performance of ecocycles. Increasing enforcement has considerable resource implications.

The success of a collaborative process is dependent on who is engaged (providers and user groups) and how well informed they are. For example, a lack of community engagement in the co-creation of ecocyles in Hammarby, resulted in poorer performance. De Ceuvel demonstrated the value of engaging user groups with relevant expertise (as built environment professionals). Given the reduction in resources available to local government, extending development timelines, engaging the public and increasing the expertise of those involved in collaborative processes maybe too costly.

The learning obtained by key stakeholder engagement in the CD process can result in the scaling-up of projects or translation of circular systems, practices and infrastructure to new locations. This is particularly true when knowledge dissemination networks are established (e.g. Amsterdam). However, the case studies demonstrated that circular transformations were unlikely where a wider supportive regulatory framework was absent. The circular construction practices learnt in QEOP were not supported outside Greater London by the national regulatory framework. Thus, there was limited demand for recycled construction materials. So construction companies have not adopted the circular construction practices more broadly.

5. Conclusion

This paper provides a more detailed understanding of CD and urban planning's role in that process. It demonstrates that planning clearly has a role, although it can be limited by many factors. CD has emerged at a range of scales (city-region to neighbourhood). A variety of actors (government, community, industry and business) are engaged in the process. Different partnerships produce different systems, at different scales. Strategic systems (e.g. circular construction or organic waste, energy recovery) emerge from industrial/ government partnerships (e.g. energy recovery system in Stockholm). Industrial actors provide new systems of provision and government supports this through procurement, capacity building, land release and planning. At a neighbourhood-scale, community/business/government partnerships often create temporary, grass-roots, circular experiments. The government's role here is to provide land, temporary planning permissions and financial support for the activities emerging from the community and business (e.g. circular Brixton).

The actors involved have different goals and competencies, which can create conflicts in the CD process (e.g. water reuse/recycling in London). The spatial plan can prioritize CD goals, which helps to guide decision-making (e.g. spatial plans for London and Paris). Planning is a negotiated process, making trade-offs between goals to enable context appropriate responses to CD. It provides an arena in which CD solutions are co-designed (e.g. Hammarby Ecocycles and De Ceuvel). Thus, the planning process can mediate between the socio-ecological and economic priorities, which create conflict and impede CD. It can also build the capacity and support for circular systems across stakeholder groups.

CD is typified by a range of low value activities which have difficulties competing in space scarce contexts. Circular activities produce low value products and services, with low market demand. Planning can intervene in markets to provide space for these activities (e.g. land release in Buiksloterham) and create demand for the services and products they produce (e.g. Amsterdam's requirement for recycled bricks in new development).

Planning also provides spaces in cities where circular development experiments can emerge (e.g. all cases). These can be used to test new planning arrangements for delivering CD. Indeed under the right conditions, where national governments learn from circular experiments, and use these lessons to inform urban policy, this will lead to the wider circular transformation of the urban development regime (exemplified in the Netherlands).

Institutional Review Board statement

The study was conducted according to the guidelines of the UCL Ethics Committee 2017.

Data availability statement

Data was obtained from third parties on the proviso the data was anonymized.

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