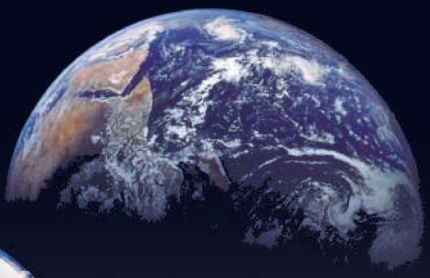
Green Energy and Technology



Adriano Bisello
Daniele Vettorato
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Smart and Sustainable Planning for Cities and Regions

Results of SSPCR 2019

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Assessing Integrated Circular Actions as Nexus Solutions Across Different Urban Challenges: Evidence Toward a City-Sensitive Circular Economy

Maria Beatrice Andreucci and Edoardo Croci

Abstract Cities across the world are actively exploring the circular economy concept, a key urban planning and design approach for the green transition, simultaneously enabling greater energy and material efficiency and lower pollution, as well as job creation, social inclusion, human health, and well-being. The city can be viewed as a complex socio-ecological system, in which infrastructures and urban forms have co-evolved along with sociocultural practices and the lifestyles of urbanites. Circular design and systemic thinking have not yet been incorporated into the planning and design of the urban built environment, and this limit has progressively created vulnerabilities and risks. Among the various urban resources, available land is often scarce, as it is natural landscape. Consequently, it is particularly important that vacant public space is re-functionalized and brownfield sites are restored. Equally, green infrastructure—urban forests, green roofs, green walls, permeable pavements, and constructed wetlands—provides critical ecosystem services (supporting, provisioning, regulating, and cultural services) at different scales: building, district, city, and region. Green elements and systems in the urban built environment regulate climate, air, and water quality; enable nutrient and water cycling and soil formation; provide space for growing food and for recreation. Using a mixed methods approach, including a literature review and case study analysis, the research identifies several opportunities and challenges to integrated circular actions, "nexus solutions" across various urban challenges, i.e., sociocultural, economic and financial, regulatory, political, institutional, ecological, environmental, and technological. The study then focuses on critical dilemmas faced when implementing nexus solutions. Providing an overview of selected international initiatives, the contribution, leveraging on an extensive interdisciplinary research, aims at showcasing how districts and cities are advancing the circular economy concept in practice. Evidence provided by projects and case studies—such as: Freshkills Park, a landfill reclamation project on Staten

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Island, in New York City; Royal Seaport, a major urban regeneration project in Stockholm; and Buiksloterham, a neighborhood and an urban living lab in Amsterdam North—are provided, aiming at testing and validating circularity at different scales. The outcomes of the conducted study identify in particular the impacts, both positive (benefits) and negative (trade-offs) of incorporating circularity into the urban planning and design processes, as well as how these can be assessed in order to stir robust systemic change in the long term.

Keywords Circular economy · Ecosystem services · Nexus · Well-being of citizens · Adaptive monitoring

1 Introduction

Urban areas currently host 55% of the world's population, projected to increase to 68% by 2050 (United Nations 2019) and are recognized as central nodes of the global economy. Urban areas spatially aggregate people, infrastructures, services, and financial resources, which generate great pressure on natural resources and evoke relevant social, environmental and economic challenges. Even though they occupy less than 2% of the Earth's surface, cities consume 60–80% of natural resources globally; they produce 50% of global waste and 75% of greenhouse gas emissions (Camaren and Swilling 2012), while the global urban footprint will triple over the years to 2030 (Seto et al. 2012).

Circularity is recognized as the paradigm that can enable more efficient production and consumption patterns, overcoming the unsustainability of the traditional linear economy. By "closing the loop" and adopting a regenerative perspective, the circular economy entails a more efficient use of resources, valuing and reusing waste in new production processes (Ellen Mac Arthur Foundation 2018).

Cities are ideal contexts to test circularity principles. The proximity of people and materials in the urban environment favors the possibility to reduce structural waste with a circular approach. Cities are also nodal points of innovation. The emergence of new technologies in sensoring, high connectivity, IoT, and big data is fostering new management practices and operations of urban systems and networks. Cities also hold the scale required to provide innovative business models and interaction patterns between firms, consumers, and local authorities.

City governments have relevant powers over spatial planning, mobility planning, building standards, and energy and water and solid-waste management, which can be leveraged to promote a more sustainable urban development thanks to circularity. Furthermore, city governments can integrate circular principles into their procurement criteria and practices, setting the example for other urban actors (URBACT 2016).

The need to foster the transition of cities toward more sustainable models is also advocated in the main policy frameworks, including the 2030 Agenda for Sustainable Development (2015), in particular Goal 11 mandating making cities and human

settlements inclusive, safe, resilient and sustainable, the UN Habitat New Urban Agenda (2016) and the new European Urban Agenda (2016); the latter identifies the circular economy as one of the twelve critical urban challenges (Croci and Lucchitta 2018).

According to the Ellen Mac Arthur Foundation (2015), a possible definition of "circular city" implies the following main features that urban systems should pursue to increase efficiency, sustainability and minimize waste:

- built environment designed in a modular and flexible manner;
- energy systems that are resilient, renewable, distributed and enable effective energy use;
- urban mobility system that is accessible, affordable, clean and effective;
- urban bio-economy where nutrients will be appropriately returned to the soil;
- production systems that encourage "local value loops" and minimize waste.

Given the complexity of cities, all these systems are interconnected. Urban circularity should therefore be linked to the concept of urban metabolism, which looks as cities as living super-organisms in which there are continuous flows of inputs and outputs (UNEP 2017).

In spite of several sectoral applications of circularity in cities, an integrated assessment of sustainability of circular integrated experiences in cities is still in its initial stage (Marin and De Meulder 2018).

Measuring the circularity level in an urban context is urgently needed. Several monitoring approaches have been proposed to measure a city's performances (C40 and Climate-KIC 2018), leading to the development of several urban sustainability indicators and indexes (Science for Environment Policy 2018), which also consider the implementation of the Sustainable Development Goals at the urban scale (Sachs et al. 2019; SDSN and Telos 2019).

Nevertheless, common and standardized city-level indicators are still lacking (OECD 2019), even if some cities have started to develop their own circularity monitoring frameworks.

In the design of urban development policies, some key circularity principles have emerged: circular supply privileging recycled and bio-based materials; resource recovery along value chains; buildings and infrastructures' life extension and refurbishment; sharing models of services and spaces; and product as a services innovation favoring dematerialization.

The integration of policies aimed at resource efficiency, circularity, and resilience presents relevant innovation opportunities to generate high added values beneficial to multiple stakeholders, as demonstrated by the projects, currently in progress, hereby presented and discussed: Freshkills Park in New York, Royal Seaport urban regeneration project in Stockholm, and Buiksloterham, a neighborhood and an urban living lab in Amsterdam. Providing an overview of selected international initiatives, the contribution, leveraging extensive interdisciplinary research, aims at showcasing how districts and cities are advancing the circular economy concepts in practice.

2 Method

Using a mixed methods approach, including literature review and case studies analysis, the research identifies several opportunities and challenges to integrated circular actions and *nexus solutions* across various urban challenges, i.e., sociocultural, economic and financial, regulatory, political, institutional, ecological, environmental, and technological. The study then focuses on critical dilemmas confronting implementing nexus solutions, showcasing how districts and cities are advancing the circular economy concepts in practice.

Only recently (2018) did the European Commission, in the circular economy action plan, commit to develop a simple and effective monitoring framework, even if not specifically focused on cities. Beyond strengthening the logical value chains among the different circular concepts, the goal of the research is, therefore, to provide input and feedback to practitioners and decision-makers by highlighting how districts and cities can be made healthier, safer, smarter, and climate-resilient through evidence-based design and adaptive monitoring. This adaptive approach acknowledges that action is necessary or appropriate with imperfect knowledge and that initial actions can be refined as more information becomes available (Andreucci 2017, 2019).

Literature and research identify several opportunities and challenges to integrated circular actions across different urban aspects, i.e., sociocultural, economic and financial, regulatory, political, institutional, ecological, environmental, and technological. Understanding and making explicit the synergies and trade-offs across a variety of outcomes and actors has proved to be critical, aiming at structuring a decision-making process in which policy makers can consider multiple objectives simultaneously.

3 Results

3.1 Design Out Waste and Pollution

It was not until the second half of the twentieth century that artists and designers, with a growing awareness of environmental issues, focused attention on the multiple relationships between waste management, public awareness, functionality, and aesthetics. Artists and designers began to challenge traditional limits and started considering landfills as settings for artwork, sport and recreation facilities, eye-catching monuments in the landscape.

The emergence of contemporary projects dealing with waste landscapes generates innovative approaches that address key urban challenges and dilemmas, transforming existing waste and landfills into productive, safe, inviting and publicly accessible green infrastructure (Andreucci 2019). Post-industrial sites are capable of bringing people closer to landfills and facilities by integrating educational, sport and recreational activities within the everyday urban environment. This approach represents

ways to develop workable strategies aimed at transforming the liability of waste management into socially attractive assets in which everyone participates.

Freshkills Park is a landfill reclamation project located in western Staten Island in New York City, along the banks of the Fresh Kills estuary. Prior to development, the area primarily consisted of tidal creeks and coastal marsh. Although the Fresh Kills landfill was originally activated in 1948 as a temporary solution to the city's increasing waste management challenges, it remained open for 53 years and received as much as 29,000 tons of trash per day during its peak years of operation, becoming the largest landfill in the world and "the only other manmade object, besides the Great Wall of China, which could be seen from space" (Trash Timeline n.d.).

Although officially closed on March 22, 2001, Fresh Kills was briefly reopened after the 9/11 World Trade Center attack in order to accept 1.2 million tons of debris from the fallen towers during a ten-month recovery effort. The 9/11 materials were screened and sifted for human remains, and the rest of the debris was placed in a 48-acre area on top of the West Mound, where a US flag in memory of the victims was installed (Freshkills Park n.d.) (Fig. 1).

The area is one of the few remaining vast open spaces in the City of New York, and consequently, the Department of City Planning and the architectural firm James Corner Field Operations developed a plan to convert this unique site into a contemporary urban park and thus alleviate the city's need for open space, while restoring the natural environment. Freshkills Park once completed, in 2036, will be almost

Fig. 1 Fresh kills, Staten Island, New York. Image credits: Maria Beatrice Andreucci

three times the size of Central Park and the largest park development project in the city for the past hundred years (Harnik et al. 2006).

3.2 Regenerate Ecosystems for People and the Environment

Royal Seaport is a major urban regeneration project in Stockholm, Sweden. This area is a brownfield redevelopment site, surrounded by valuable green and water ecosystems. The northern area of Hjorthagen is currently under construction, with several residential buildings completed. Industrial areas (e.g., a gas works plant and district heating plant) on site will soon be closed down. Two cruise ship terminals are still functioning successfully, attracting tourists and visitors.

The Strategic Urban Development Plan for the Stockholm Royal Seaport ultimately aims at providing health, safety, comfort, and better quality of life in the district. Such aims can only be achieved through a balanced portion of environmental, cultural-social, economic and governance sustainability within an ongoing business-oriented spatial development (Huang et al. 2017).

In order to tackle the above challenges and dilemmas, the existing plan for Royal Seaport has set environmental targets of reaching CO_2 emissions not more than 1.5 tons per capita by 2020 and to become fossil-fuel free by 2030. These targets are being supported by the applications of cutting-edge environmental technologies, including smart grids, smart communications, eco-cycle waste management, biogas and electric cars, and sustainable buildings in the form of active houses (Fig. 2).

It must be noted that Royal Seaport took a holistic people-oriented approach through the development of various activities that encourage more active engagement by the residents, not only as users or consumers, but as design activists during all stages of planning, design, and monitoring of the implementation toward highly ambitious circular economy targets and environmental standards.

Fig. 2 Royal Seaport, aerial view. Image credits: www.stockholmroyalseaport.com

Through the vision "The Way We Green", Stockholm is proposing that the Royal Seaport should not only become a world-class circular city district but most importantly should be transformed into a livable waterfront district, for its residents to live and work in good health, comfort, safety, and with high quality of life. Thus, the Stockholm Royal Seaport is designed with the focus not only on economic and environmental sustainability, but also putting emphasis on equity and inclusiveness.

3.3 Keep Construction Materials, Components, and Systems in Use

Buiksloterham is a neighborhood and an urban living lab in Amsterdam North. It is in a unique position to serve as both a living test bed and catalyst for Amsterdam's broader transition to becoming a circular, smart and bio-based city.

Within Amsterdam, Buiksloterham is a peculiar case: Though it has been treated as a functionally marginal district because of its industrial history, it is located close to the historical center of Amsterdam, across the IJ River (Gladek et al. 2014).

Unlike most other centrally located neighborhoods, Buiksloterham is a comparatively blank canvas with many empty spaces and almost no heritage buildings. This status creates space and offers flexibility for new developments (Gladek et al. 2014). Buiksloterham has been conceived as a device for the broader transition of Amsterdam. Its polluted lands and bare plots are gradually becoming the center of the implementation of innovative clean technologies and a hub for the closure of urban material cycles. People and activities needed to "close the loop" are critical resources and act as a driver for the local business, while establishing local social ecological systems. IT-based programs and devices will connect smart residents with one another and boost the effectiveness of resource flows. Urban biodiversity and climate-adaptation measures are conceived as an integrated strategy to bring long-term benefits to the area. Buiksloterham consequently can represent a blueprint and a living dynamic lab, i.e., a virtuous example for other marginal areas worldwide that can effectively be transformed into powerful engines for inclusiveness, diffused quality of life, and business regeneration in cities (Fig. 3).

4 Discussion

A circular economy promotes the adoption of state-of-the-art integrated systems of waste management leveraging on appropriate technological development (Schumacher 1973) and nature-based solutions, as well as the improvement of practices for the protection of nutrients and soil and the conservation of materials and energy resources, as opposed to relying on fossil fuels and to encourage indiscriminate consumption. A circular economy identifies and transforms the negative impacts of

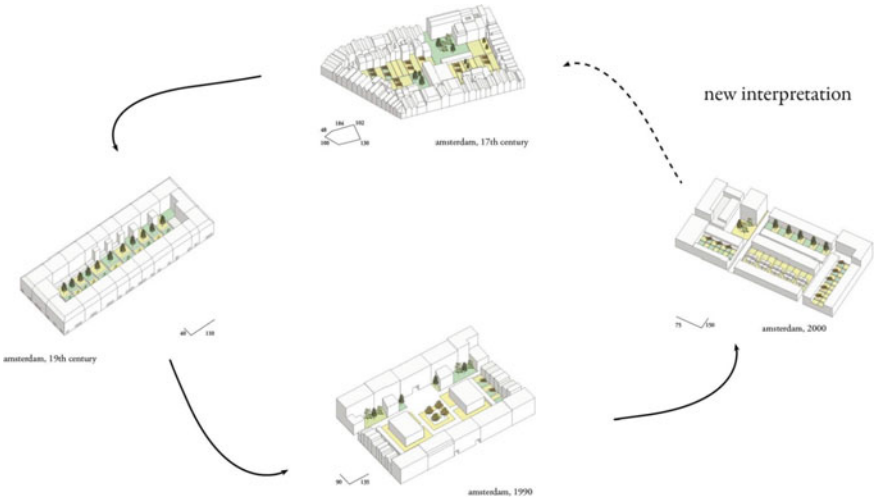

Fig. 3 Buiksloterham for circular Amsterdam by Studioninedots and Delva landscape architects

industrial activities that threaten human health and our natural capital, acknowledging that the majority of costs that we are directly or indirectly paying today are due to GHGs (36%), water consumption (26%), and improper land use (25%) (Trucost, 2013). Under this logic, Freshkills Park in New York City, once completed, will transform the liabilities of a degraded and polluted land into an attractive opportunity for inclusiveness and recreation. Addressing impacts from air, land, and water pollution will also result in significant environmental and social costs savings.

Circular economic model seeks to decouple real-estate development from soil consumption and natural capital depletion. A circular real-estate sector addresses resource-related concerns and promotes balanced solutions progressing business models and bottom-up initiatives able to generate sustainable growth, create jobs, and reduce environmental impacts such as carbon emissions. As the call for business models based on systems thinking grows louder, "design for people" practices leveraging the alignment of technological factors and social needs can empower the urban transition to a circular economy. The redevelopment of Royal Seaport in Stockholm—preserving and enhancing its natural capital by controlling the brownfield requalification and balancing business with quality of life—represents an inspiring example of how natural systems restoration combined with active people engagement can produce synergies at various different scales.

A circular economy favors activities that preserve existing values. With the right design approach, new systems and services to reuse materials and save energy, labor, and other resources used to generate them can be created. Virtuous production cycles characterize and differentiate the circular economy model from the "disposal and recycling" one, where large amounts of embodied energy and natural resources are inevitably lost. When aiming at "closing the loop", artifacts are designed using good quality materials and optimized for disassembly and components' reuse, making it

easier and faster to transform or refurbish them. This implies designing for reuse, remanufacturing, and recycling to keep construction materials, components, and systems circulating in the economy, while advancing innovative businesses and processes also through the adoption of new business models. The economic co-benefits include increases in overall consumption and spending encouraged by lower prices. In "Buiksloterham for circular Amsterdam", making effective use of innovative clean technologies and closing local material flows will certainly act as a powerful driver for jointly promoting the local industry, the overall city image, and ultimately the quality of life of its inhabitants.

5 Conclusion

Cities across the world are just starting to implement the circular economy approach, as it has been only recently recognized as a key urban planning and design paradigm for a green new deal, simultaneously enabling greater production efficiency and lower emissions, as well as job creation, social inclusion, human health, and well-being, at all scales.

The implementation of an integrated circular vision in cities can bring significant economic, social and environmental benefits. It can foster the emergence of wealthy, robust, and inclusive cities. Such wealthy cities are where economic efficiency increases through improved mobility, designed out waste, and lower costs and where new developments and business opportunities support innovation, skills development, and job creation. Robust cities have improved quality of life and urban metabolism, reduced emissions and soil pollution, and enhanced social interactions. Inclusive cities prioritize caring for social needs while keeping materials and systems in use, thus reducing pressures on scarce resources and minimizing conflicts, engaging with both local communities and other relevant stakeholders, and taking advantage of digital technology (Ellen Mac Arthur Foundation 2019).

Multiple benefits can be achieved by changing how cities are planned, restored, financed, and managed. An integrated and balanced vision is needed to help address key urban challenges impacting social integration, housing, mobility, and sustainable economic growth. The circular urban economy advances the 2030 Sustainable Development Goals, as well as the UN Habitat New Urban Agenda and the new European Urban Agenda, supporting the reduction of greenhouse gas emissions and the adaptation to and mitigation of the effects of climate change.

Decision-makers and politicians are critically positioned vis-à-vis the success of a true transition to a circular economy—visionary administrators are the ones who can empower, manage, and engage key stakeholders from across the public and private sectors, using a wide range of policies and measures, encouraging innovative business models and inclusive approaches. Ultimately, the call is for a collaborative, holistic transition integrating resilience, efficiency and circular economy principles to benefit livable, inclusive, and competitive urban environments, as well as the people who animate them.

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