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CREATING CIRCULAR NEIGHBOURHOODS

A DISCUSSION PAPER



United Nations Environment Programme

CREATING CIRCULAR NEIGHBOURHOODS

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Prepared in cooperation with: Arup, BASE, C40 Cities, Ellen MacArthur Foundation, MASS Design Group, The Ministry of Environment of Mexico City, and Prague Institute of Planning and Development.

About this paper: This discussion paper is meant to inspire city actors (communities, governments, and businesses) to initiate circular economy activities at the neighbourhood level. Drawing from the experiences of Mexico City and Prague, as well as from the experiences of the writing team, we put together some initial thoughts around circular construction, servitisation, and neighbourhood food systems.

The paper elaborates on circularity under the umbrella of the UN Environment Programme's broader efforts at engaging communities in sustainable urban development through a 'neighbourhood approach'. It provides arguments for including neighbourhoods in circular economy planning and monitoring in cities.

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GLOSSARY

(Urban) Food systems

(Urban) Food Systems can be defined as “a set of activities ranging from production through to consumption” (in an urban setting)¹. This includes, but is not limited to, domestic food production, urban agriculture production, wholesale markets, food processing industry, and restaurants².

Circular buildings and construction

Circular buildings and construction is about maximizing the lifespan and reusability of entire buildings or building materials from the start of the design process, while optimizing resource consumption - i.e. reducing material inputs and avoiding construction and demolition waste³.

Circular Economy (CE)

The circular economy is built on three principles, driven by design: eliminate waste and pollution, circulate products and materials (at their highest value), and regenerate nature.

Construction and Demolition Waste (CDW)

Construction and Demolition Waste is a type of waste generated by any activity involving the construction, renovation, repair or demolition of buildings or infrastructures. It consists mainly of inert and non-biodegradable materials.

Cooling or Heating as a Service (CaaS or HaaS)

Cooling or Heating as a Service is a servitisation model applied to cooling and heating systems. By using CaaS or HaaS, upfront investment in cooling/heating technologies is eliminated for the users, who instead pay per unit of cooling/heating consumed. CaaS and HaaS are often associated with clean technologies and they strengthen incentives for efficient and thoughtful consumption⁴.

Material Banks

Material Banks are buildings that function as stores of valuable materials, building materials and building systems. Considering buildings as material banks allows the value and functionality of their materials and components to be preserved for reuse, reducing the need to exploit primary resources⁵.

Municipal Solid Waste (MSW)

Municipal Solid Waste is defined as “waste generated from domestic and commercial activities by natural persons that is collected and treated by municipalities”. Even if national definitions may differ, MSW usually excludes municipal construction and demolition waste⁶.

Neighbourhood

A neighbourhood is “generally defined spatially as a specific geographic area and functionally as a set of social networks”⁷. Neighbourhoods encompass geographically localised social communities within a larger area (either a city, a town, etc.).

Power Purchase Agreements (PPAs)

A Power Purchase Agreement is defined as “a contract between two parties, one who produces or generates power for sale (the seller/ producer) and one who seeks to purchase power (the buyer/ offtaker)”⁸.

Resource efficiency

Resource efficiency means creating more value with less input of resources, thus minimising impacts on the environment, and is expressed as a ratio of the amount of product or service obtained by unit of resource used.

Servitisation (or Product as a Service, PaaS)

Servitisation (or PaaS) is a business model that allows customers to purchase the services and outcomes of a product rather than the product itself. For example, in this model, washing machines could be installed at the neighbourhood level, while the community would only pay per usage of the machines, usually through subscriptions.

Vernacular architecture

Vernacular Architecture refers to a type of architecture that is indigenous to a specific time and place and that uses local traditional materials and resources.

KEY MESSAGES

While neighbourhoods are not a political entity nor rigidly defined, they have a key role in the circular economy (CE) transition and need to be included in the development and implementation of CE strategies.

A closer look at circular construction, servitisation, and urban food systems of Mexico City and Prague gives examples of how neighbourhoods can be powerful entry points and sources of inspiration for circularity in cities. The neighbourhood is a scale that allows for the design and operation of “living labs” – large enough to be representative of community behaviour and their interactions with urban systems.

Local government action is critical to creating circular neighbourhoods.

Community-initiated activities are an effective starting point, but city level action is essential to accelerating the circular economy transition. Replication and scale-up needs to come with government support – even if the action happens at the neighbourhood scale. Both Mexico City and Prague empowered neighbourhoods – the households and businesses in them – to engage in circular practices.

Circularity in neighbourhoods transforms the relationship with existing systems.

It catalyses not only a change in cities’ built environment but also a change in the values and behaviour of the community, and potentially the mindset of a city’s population. The neighbourhood scale makes circularity more tangible. It is easy for many to understand new jobs from circular construction, access to nutritious food through circular food systems, and energy/cost savings through servitisation. The neighbourhood scale is a starting point to make circularity real to residents and local business alike. People are able to see waste as assets and begin to value once again what is already there. It brings communities together as they try to optimise use of shared (community) assets such as buildings, green open space, and (energy) systems.

There are multiple opportunities to create circular neighbourhoods in different systems in cities.

This paper took snapshots of sectoral systems and did not analyse the entire city. But in this limited scope, this paper found concrete ideas on how to move towards circularity. Each sector encouraged us to look at other systems within the city and within neighbourhoods.

- **Circular construction** provided a window to the system of structures that make up a city. Neighbourhoods could be turned into material banks and that there is room to change local regulatory/policy framework to allow local construction and repair.
- **Servitisation** offered possibilities for change in how systems in our homes work. From electricity to appliances, returning responsibility to manufacturers/service providers transferred performance risk from consumer to provider, encouraging maintenance instead of throwing things out.
- A snapshot of **neighbourhood food systems** revealed the multiple benefits of community gardens – connecting us to nature and creating a shift in mindset towards circularity.

Neighbourhoods provide an opportunity to address the dependence on existing linear networks.

By deconstructing cities into smaller action areas, it is possible to identify starting points for a radical transformation towards circularity. It is in these spaces, these neighbourhoods, that one finds inspiration to reimagine, redesign, and rebuild the cities we live in.



1. INTRODUCTION

1.1

A NEIGHBOURHOOD APPROACH TO A CIRCULAR ECONOMY

Even the most complex cities are comprised of neighbourhoods, where people can meet their daily needs, socialise, and feel safe¹. Even though they are not defined by political boundaries, neighbourhoods are the systems that people, and households are most connected to. They are dynamic and evolving, feeding into and from the broader construct of the city. The neighbourhood scale allows cities to take smaller bites of seemingly insurmountable problems like unsustainable consumption, biodiversity loss, pollution, and climate change. Instead of seeing one impregnable spatial unit, the city can be perceived as smaller units – neighbourhoods – where people interact, and change can be clearly envisioned.

There is an opportunity to use the neighbourhood scale as an entry point for change as cities across the globe are designing interventions that seek the many benefits of a circular economy transition^{2,3}. In Europe circularity in the mobility, food, and built environment sectors could lead to emissions reductions of 48 percent by 2030 and 85 percent by 2050, compared with 2012 levels⁴. It has also been estimated that doubling 2020 levels of circularity, estimated at 8.6%, would reduce global emissions by 39 percent by 2032 and ensure that global average temperature rise is kept below 2 degrees⁵. Furthermore, a European Union study estimated savings of USD 340 to 380 billion every year for a baseline circular transition scenario, and more than USD 600 billion with more aggressive scenarios⁶. Given the 'win-win' scenario that a circular economy paints, it is not surprising that circular initiatives and innovations have been flourishing in cities in the past few years, with a growing number of start-ups and pilot coalitions emerging⁷.



Local governments have a significant role in creating the enabling conditions for successful bottom-up action. Conversely, neighbourhoods can initiate action and inspire local governments. Taking ideas from various sources, the paper illustrates that every neighbourhood in the world has the capacity to develop initiatives and innovations that contribute significantly to the development of circular cities. This paper looks to two case study cities – Mexico City and Prague – for inspiration on how cities support circularity in neighbourhoods and vice versa.

Using the three focus areas of circular construction, servitisation, and circular food systems – that will be elaborated on at a later point – neighbourhoods can effectively implement and contribute towards accelerating circular economy transitions. This paper focuses on the question:

What is the role of neighbourhoods in accelerating a circular economy transition?

As this question is explored, this paper looks both at how local governments can support circularity in communities/neighbourhoods while at the same time exploring how the private sector and community-led actions, or initiatives that emanated from the neighbourhoods, could contribute/are contributing to overall circularity in cities.

1.2

A FOCUS ON MEXICO AND PRAGUE



Aerial pictures of Mexico City



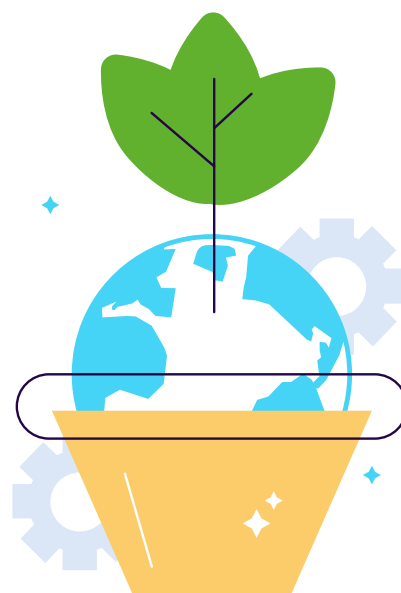
Aerial pictures of Prague

1. INTRODUCTION

City governments have a critical role in creating an environment that empowers communities in neighbourhoods to act. They establish and manage the regulatory framework and enabling conditions to support change in how materials are used and managed in neighbourhoods. Cities could pass laws and implement policies that stimulate circular economy practices (e.g., changes in building codes promoting reusing materials and construction and demolition waste). Local governments can also facilitate partnerships to implement circular economy projects in neighbourhoods. They can engage the private sector, community groups, and other civil society organisations to finance, conduct awareness raising, and build capacity on circularity.

But each local government is different and the way each city supports specific neighbourhoods are also influenced by their own culture and politics. It is for this reason that UNEP and partners chose two very different cities from which neighbourhood snapshots on circularity are drawn.

Mexico City and Prague are not only geographically distant, they are also radically different. While both cities have mostly multi-level residential buildings, Mexico City's building stock traces its roots to the colonial wave of urbanization in the 16th century. Some structures in Prague go back to the 10th century. Mexico City is home to about 9 million and Prague to 1.3 million. Both cities are among the world's wealthiest, with Mexico City's GDP at around US\$266 billion (US\$30,000 per capita)⁸ and Prague's at €53.6 billion (US\$63 billion, US\$52,000 per capita) in 2019⁹. However, wealth inequalities are a critical issue in Mexico City, with a Gini coefficient of 0.5320 in 2018 in the city (well above the national average of 0.4688)¹⁰. Given these differences, the neighbourhood approaches in both cities cannot be compared. It is instead, the diversity of neighbourhood types and approaches that is explored in this paper.



There are also similarities. Mexico City and Prague are both capital cities and selected for this discussion paper given their leadership in the circular economy space. The two cities have included circular strategies as part of their climate action plans, the 2030 Climate Plan for Prague¹¹ and the Mexico City Climate Action Program (PACCM) and Local Strategic Climate Action Plan (ELAC)¹². Prague is also working on aligning their 2030 Circular Economy Strategy with their Climate Plan. The city has an ambitious target of cutting down emissions by 45 % by 2030. Within this target is a commitment to rethinking the consumption patterns of resources in the city, particularly energy, water, and transport, and in parallel, realising the full potential of circularity in the materials the city needs to thrive. Mexico City is working towards a 10 percent reduction in emissions and an increase in the adaptive capacity of ecosystems, strategic infrastructure, communities, and their livelihoods by 2024.

Mexico City and Prague also face complex governance systems in the implementation of their circularity strategies. Mexico City is a state agency that coordinates actions of 16 independent municipalities¹³ while the city of Prague includes 57 municipal districts and 22 administrative districts¹⁴. The coordination required to implement an integrated circular economy plan often poses an issue for the two cities¹⁵. A neighbourhood approach to circularity presents an opportunity to break down governance issues into smaller independent units.

The paper will be using illustrative cases and examples from Mexico City and Prague to highlight how local governments and neighbourhoods interact in the circularity space using the lens of construction, servitisation, and food systems.



2. CIRCULARITY IN KEY FOCUS AREAS

2. CIRCULARITY IN KEY FOCUS AREAS

There are many ongoing efforts that focus on transitioning cities from linear to circular, but only a handful¹⁶, that highlight the intersection of communities, built environment, and local government effort¹⁷. Acknowledging that much of the information would not be in existing literature, an experienced group of collaborators came together to reflect on the complexities of circularity at neighbourhood scale, through this discussion paper. Collaborators of this project (listed in alphabetical order) include Arup, BASE, C40 Cities, Ellen MacArthur Foundation, MASS Design Group, Mexico City (Ministry of Environment and Secretary of Urban Development and Housing), Prague Institute of Planning and Development, and the United Nations Environment Programme. All are invested in supporting neighbourhood engagement for cities to transition from a linear to circular and are keen to deepen this discussion, using this paper as a starting point.

Drawing from varied information sources, and building on the inputs from the expert team, the paper focuses on three areas for exploring and inspiring circular transition interventions: (a) circular construction; (b) servitisation (contributing to resources efficiency, to the energy efficiency and renewables transition); and (c) neighbourhood food systems.

This paper draws on valuable insights from the expert team's rich practical experience. For example, the work of MASS Design Group on sustainable buildings and construction in Africa (notably Rwanda); BASE on sustainable energy and innovation around delivery of products-as-a-service (e.g., the global Cooling-as-a-Service initiative); C40's Clean Construction Programme with Mexico City as a pilot; and, Arup's various projects across Europe where they exhibit implementation of circular design and construction techniques in both greenfield and brownfield development that unlock value in real estate markets using circular economy principles¹⁸.

UNEP, for its part, has been exploring sustainable consumption and production and circularity for decades, and is looking to better understand its implications at the neighbourhood scale. The paper looks at bottom-up city transformation through UNEP's Integrated Guidelines for Neighbourhood Design¹⁹, as well as the recent Arup and C40 collaboration around green and thriving neighbourhoods of which circularity is one of the 10 approaches²⁰.

Going further, this paper also builds on existing literature including a couple of reports from members of the writing team, Arup and Ellen MacArthur Foundation - one that highlights and summarises some of the latest global thinking on circularity and the built environment (prolonging an asset's life, decreasing resource use, and implementing innovative solutions²¹)

and another that outlines the critical role of local and city governments in creating the enabling conditions for circular neighbourhoods by embedding circular economy principles into urban policy levers²².

As introduced earlier, the paper focuses on circular construction, servitisation, and food systems as three focus areas with replication potential and neighbourhood impact. These three are:

- Tangible to the neighbourhoods and households, addressing basic needs like food, housing, heating/cooling.
- Areas that operate or can potentially operate at a small enough spatial scale that is representative of communities, and underlying urban systems.
- Not prohibitively expensive and can be started by municipal governments, building owners, property associations, and by communities themselves at a moderate to low financial risk.
- They have a high impact on material consumption and related carbon footprint.

While waste and waste management are central to the circular economy narrative, the paper does not focus on it independently, but rather explores opportunities in which it can be connected and contribute towards addressing certain elements of the complex topic of waste management.



2.1

CIRCULAR CONSTRUCTION

It has been estimated that the construction sector accounts for one third of global material consumption and waste, which is only expected to increase with current global trends in new urbanisation — a recent study projected that the global construction output will grow by 85 percent by 2030. Adding to these worrying trends is the fact that technologies in use today in the sector rely on materials and methods that either directly or indirectly generate more than 40 percent of greenhouse gas emissions in cities.

Over the last decade, the introduction of circularity into the buildings and construction sector has brought a resurgence of interest in vernacular architecture, where urban planning and building design, out of necessity, had local materials and environmental considerations in mind. Modern architects are rediscovering in traditional design, strategies to reduce energy consumption because traditional design and construction techniques had to address challenges like heat and cold prior to the introduction of electricity²³.

A neighbourhood approach to circular construction could bridge traditional and modern building techniques. Residents and local businesses in neighbourhoods are best placed to answer questions such as whether buildings need to be demolished, if a space is responsive to their needs, and how a structure responds to the local environmental systems²⁴. These are all critical to ask as experts rethink their design process, construction methods, and the entire materials supply chain, in an effort to move the construction sector from linear to circular.

Neighbourhoods could be 'sandbox' environments that support development of micro solutions and test replicability and scalability of good practices. This can include exploring the feasibility of using local materials and shortening supply chains; and focusing on design aspects that are responsive to local environmental

and socio-economic needs. These small scale 'experiments' in circular construction²⁵ generate valuable evidence for the processes employed, which could then be used to strengthen existing building codes and regulations.

A better understanding of community needs can reduce the overall use of materials in new build or the need for new build altogether. Circular construction looks into extending the end-of-life use of materials and building components²⁶ — reusing entire buildings where possible, and designing new buildings for assembly, disassembly, and recoverability, taking into consideration local technological and biological circular materials flows²⁷. By doing so, buildings can be conceived as "material banks", making them easier to repair, refurbish and reuse. Evidence can already be seen of this in informal housing²⁸ — albeit at a much smaller scale — but it needs to be taken to a wider scale and become applicable to more material-intensive high-end developments. In Europe, cities are beginning to support community networks that collect and reuse building materials, as well as set up pilot projects for circular construction²⁹.

2. CIRCULARITY IN KEY FOCUS AREAS

Material banks can shorten supply chains, strengthen repair networks, and revitalize traditional building practices. But this requires a significant reform in regulation³⁰. The buildings and construction sector has invested in global supply chains and standardized practices. In many countries, this translates to building codes and standards that restrict mainstreaming of certain (local) materials, or (traditional) designs (e.g., earth construction in general, grey water reuse, and tall mass timber buildings), or even innovation in terms of materials used in construction (e.g., mass timber). Such gaps in regulations can hinder agile processes and need to be changed in order to build circularity in the built environment³¹.

A tool that could accelerate the uptake of “material banks” is the “building passport”. It documents key building related information, thereby allowing stakeholders to make decisions on recycling and reuse of buildings³². This can potentially change how materials and components are chosen, designed, joined, and layered to be recovered, their value retained, and meaningfully cycled^{33,34}. While most of the innovations illustrating this concept are not yet being used at the neighbourhood scale, it is a potential area where neighbourhoods can contribute to circularity.

Example of new buildings designed by prioritising longevity and adaptability: the design and construction of the Rwanda Institute for Conservation Agriculture (RICA) campus [\[link\]](#)

Inspiration from Kigali, Rwanda

RICA is a first-of-its-kind climate-positive campus which was conceived and funded by the Howard G. Buffett Foundation, supported by the Government of Rwanda, and designed and built by MASS Design Group. The project prioritised low embodied carbon, and use of natural and local materials (stone foundations, earth walls and timber roofs). For the infrastructure, soft engineering solutions like swales and sloped banks replaced the typical culverts and retaining walls. These design decisions led to 96% of materials by weight being sourced in Rwanda, a landlocked country, and a 60% reduction in embodied carbon.

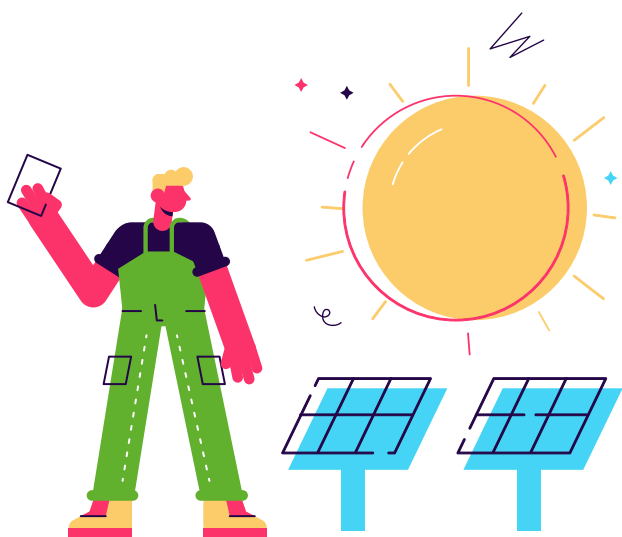
The campus relies on natural systems for user comfort such as passive ventilation and daylight. All remaining power requirements are supplied via an on-site solar array. The potable water is extracted and treated on site and the waste water is also treated on site. Furthermore, the campus conserves and expands an at-risk Savanna woodland enriching the biodiversity of the area and sequestering additional carbon dioxide from the atmosphere, leading to a climate positive campus before 2040. [\[Link\]](#)



2.2

SERVITISATION

Servitisation improves resource and energy efficiency at the neighbourhood or household level, while reducing overall costs. A well-known example is the multibillion-dollar solar photovoltaic industry, enabled through the implementation of power purchase agreements (PPAs) whereby customers, instead of buying the solar panels, pay per kilowatt hour consumed, while the ownership, operation, and maintenance remains the responsibility of the solution provider.



The concept of product-as-a-service or servitisation is giving consumers access to a service, an output or outcome instead of having to invest in the equipment needed to generate it. The consumer only pays for the units they consume, while the asset stays in the ownership of the party providing the solution. This becomes very relevant at household and neighbourhood scale because through servitisation, individuals benefit from state-of-the-art technologies (e.g., energy efficient appliances) without the need for upfront investments, while also receiving optimised maintenance and repairs without the need to pay more for it. But equally important, customers become more aware of their overall consumption which encourages them

to behave more sustainably (this has been seen in cooling/heating as a service and in preliminary results of washing machines as a service as well).

Circularity in servitisation lies in the model itself. As the ownership of the equipment stays in the hands of the technical provider, the model creates incentives for the provider to design goods with longer durability and to extend product life through repair and remanufacturing, to maximise value recovery at the end-of-life, and to optimise resources efficiency across the entire product life cycle³⁵. Further, it incentivises improvements in operation performance through research and development, maintenance practices shift from corrective to preventive, and promotes system thinking, for instance combining heating and cooling, incorporating thermal storage or renewable electricity. Businesses can also incorporate relevant technologies (e.g., machine learning) to improve monitoring, operation, and customer experience.

Change in consumer behaviour has also been seen in the experience of servitisation of cooling/heating services in residential/real estate market of Cooling as a Service (CaaS) and Heating as a Service (Haas). CaaS and Haas demonstrate that servitisation strongly addresses the challenges of stranded assets, improved energy efficiency, and consumer behaviour, while successfully promoting circularity and lowering GHG emissions³⁶.

Inspiration from the Netherlands

In 2014, Bundles was founded in The Netherlands to offer washing machine subscriptions paid on a monthly basis, providing households access to high quality and sustainable technologies. The appliances used for “Washing machines-as-a-Service” consume less water, less energy, reduce unnecessary waste (by using as well less detergent) all while providing guarantee for repair and maintenance to systems that break down. Currently the company also offers tumble dryers and dish washers on a monthly-basis subscription, and coffee machines on a pay-per-cup-basis subscription.

[\[link\]](#)

Neighbourhood level interventions are one of the ways to slowly transform urban food systems, ideally in parallel with large scale efforts to address the entire food and agriculture industry. A significant volume of work is being done to integrate food waste into circular transitions: from composting in green open spaces to create fertilizer; to recycling projects, where food waste (biomass) can be used to create biogas⁴⁴.

Inspiration from Lambeth, London, England

Arup with Incredible Edible, Incredible Edible Lambeth CIC (IEL), a community interest company, are working with Lambeth, Southern London, England to map its food growing potential to increase community food production. The first phase which focused on data gathering was from April-July 2021. The team used top-down and bottom-up strategies in its analysis. For the top-down, GIS mapping and desktop research was done to collate, analyse, and visualize freely available open-source databases. In parallel, the team did a crowdsourcing exercise where residents, businesses, and non-profits identified and recorded food growing spaces using their mobile phones. In this exercise, residents literally pointed to pocket gardens and spaces – regardless of ownership – where they would like to grow food. This was recorded in a shared database and analysed based on feasibility and need. The Lambeth experience shows that multi-level data is a critical first step to understanding what the needs of the community are. [\[link\]](#)

2.3

NEIGHBOURHOOD FOOD SYSTEMS

In the past, neighbourhood food systems were a vital part of local communities, but this has changed due to increasing globalisation of supply chains and food markets³⁷. Of late, urban food systems (UFS) have been characterised by a disconnect between the city's food source within its immediate vicinity, resulting in an ever increasing reliance on industrial supply chains³⁸. The industrialisation of food has also reduced diversity in retail options for both consumers and traders³⁹. Consumers are less aware of the origin of their food, adding to the unsustainability of the social, ecological, and economic components of UFS⁴⁰.

Major concerns have been raised for the past decades regarding globalised food markets⁴¹. There are calls for UFS to be conceptualised at a more localised level with a critical rethink of how actors interact with supply chains, the surrounding natural and built environments, socio-economic dynamics, and governance⁴². Studies have also discussed at length the inclusivity, adaptivity, and resilience that more localized food systems bring to cities⁴³.

2. CIRCULARITY IN KEY FOCUS AREAS

It is estimated that on average, close to 44 percent of municipal solid waste is organic waste, and most of this is composed of food waste⁵⁶. A recent study pegged the economic cost of wasted food across households, retail, catering, and manufacturing at US\$680 billion in industrialised countries and at US\$310 billion in developing countries⁵⁷; given current population trends, it can only be expected that this value will increase over the coming decades.



An example of urban gardens is the Altepétl programme in Mexico City: the programme aims to promote sustainable agricultural production activities and the rescue of the pictorial heritage of the inhabitants of the conservation land to contribute to well-being, social and gender equality. [\[link\]](#)

2. CIRCULARITY IN KEY FOCUS AREAS

However, while anaerobic digestion is an important strategy, it is more important from a circular transition point of view to minimise, if not eliminate, food waste. It has been estimated that globally, about a third of all food produced for human consumption is wasted, bearing significant social and environmental costs⁴⁵. In line with a circular economy transition, interventions could be designed/tested to target food waste at the community level.

Another opportunity for a neighbourhood approach in urban food systems relates to linking with the city's deep connections with supply chains that extend far beyond their own boundaries. Industrialisation of food systems have resulted in a movement away from regenerative sustainable agricultural practices, that depletes the natural resources and affects the quality of life not only within the city, but also in the regions that produce for the city⁴⁶. Localising food supply chains and nutrient cycles is a possible solution to shoring up urban food security and resilience⁴⁷. Using urban gardens as a testing ground, experiments, and innovations for shortening food supply chains and regenerative production could be implemented. These experiments may even have the additional benefit of specialised job creation and economic diversification at the sub-city level.

Less prominent in circularity discourse, but arguably very critical, is the impact of green open space on the mindset of people in the way they use land, and connection with nature. Access to a well-maintained and accessible green open space would, for example, make it more acceptable to live in smaller apartments as seen in major cities⁴⁸. Urban gardens take this to another level, as they also contribute towards a circular mindset by increasing people's appreciation of food systems and nature⁴⁹. An understanding of seasons and sources of food is especially valuable in young children who have been disassociated from food production processes and its intrinsic complexities. Neighbourhood-level urban gardens, and the localised food supply chains generated thereof could provide a space for developing hands-on learning and development opportunities for children and adults alike⁵⁰.





3. WHAT CAN NEIGHBOURHOODS DO?

3. WHAT CAN NEIGHBOURHOOD DO?

Expert opinion and literature (Section 2 above) supports that the three selected focus areas are good entry points for integrating circularity practices such as extending product life, treating waste as a resource and changing consumption patterns. All three also can reduce overall material use and trigger circular thinking.

3.1

MEXICO CITY

There is a lot to learn from Mexico City in terms of the three focus areas.

Communities are benefiting from the recycling of construction and demolition waste (CDW) in Mexico City some of which was used to develop a new open space in Cuitláhuac Park. Inaugurated in 2020, the park was constructed on a (properly rehabilitated) previous dump site and 85% of materials for the park works were recycled CDW⁵¹. This is part of a broader government green public procurement strategy encouraging the use of recycled materials. Extending for 145 hectares and using native plant and tree species to protect biodiversity, Cuitláhuac Park created an urban green space in the Renovación neighbourhood of Iztapalapa, a municipality with among the lowest levels of access to green spaces in Mexico City. Mexico City can build on its success in recovery of materials in Cuitláhuac Park by building a programme for buildings as 'material banks' and promoting existing deconstruction and disassembly practices to reuse materials and building components. The city currently generates about 14,000 tonnes/day of CDW⁵², reskilling people to manage CDW, and build/repair with it, could potentially create new jobs for the city.

Servitisation of renewable energy (solar photovoltaics) is already being offered by businesses all over Mexico, including Mexico City. Solar powered electricity is currently being offered through a service-type business model, power purchase agreements (PPAs). Solar power via PPAs in Mexico have generated savings of up to 50 per cent on household electricity bills⁵³. Yet, in spite of its success, regulatory barriers are making it difficult to take solar to scale. A subsidized electricity tariff from the state-owned electricity utility system currently makes PPAs non-competitive. If PPA prices were to be subject to a subsidy that would make them as competitive as the tariff from the grid, this would not only provide a fairer field for solar, but would also generate government savings, as the price of PPAs is

roughly half of the non-subsidized electricity cost. There is also potential in connecting existing national programs, such as the one to swap refrigerators for more energy efficient models, to a servitisation model. The national program does not consider overall material use. Aligning incentives via the use of the servitisation model would create an opportunity to address both energy and materials. Such a scheme would greatly benefit from the existence of a recovery programme that engages neighbourhoods to collect and recycle old units which are non-operational, energy inefficient, or using chemicals which are bad for the environment (e.g. those that use ozone depleting refrigerants).

Most promising, in terms of a neighbourhood scale intervention, is in Mexico City's efforts to make their food system more circular. Mexico City's community gardens enable and encourage community participation in circularity and could be replicated globally. Mexico City is investing for example in the "Mercado de Trueque", an exchange network where residents can barter recyclables (anything from paper to used cooking oil) for government vouchers that they can exchange for fresh produce grown by local farmers. In 2019, the Mercado de Trueque managed to prevent around 145.96 tonnes of waste from ending up in landfills, and about 130,000 Kg of raw materials were saved⁵⁴. The "Mercado alternativo de Tlalpan", an organic producers association, also unites more than twenty local and regional organic producers that revalue traditional agriculture. Such initiatives suggest that there are practical opportunities to scale up Mexico City's successful community gardening experience and link it to the city's circularity ambitions.



Mexico City's Community Gardening Programme

As of 2017, over 63,000 people have participated in community gardening in Mexico City⁵⁵ and many of the gardens incorporated composting and promoted the processing of organic waste. Mexico City's Bordo Poniente composting plant already produces 223.07 tonnes per day of compost and is managed by the government for the treatment of organic waste generated in the city⁵⁶. With about half of the city's waste being organic, addressing this waste stream at source reduces waste that needs to be transported.

Mexico City's community gardens have also become spaces that educate communities on how the food system works, giving people the opportunity to reflect on the ecological impact of conventional agriculture vis-à-vis regenerative alternatives. The founders of a community garden in the Cuajimalpa district, for example, take pride in growing native squash species such as chilacayotes and calabaza⁵⁷. The effectiveness of Mexico City's efforts in creating neighbourhood community gardens can be attributed to various interventions by the local government, including tax incentives for rooftop gardens, training support for community leaders, and the provision of land. The Mexico City Government has invested 1.33 billion MXN pesos (approximately USD 66 million) through its Sembrando Parques program (Planting Parks) to recover 1,199 hectares of public space in the city, with the aim of expanding the existing public space network.

Co-benefits of community gardening in Mexico City
Climate action: To mitigate climate change induced extreme heat, Mexico City invested 13 million MXN (USD \$650,000) in the development of rooftop gardens, resulting in 12 rooftops with an area of 8,468.1 m².

Culture: The preservation of native plant species is urban farms contributes to preserving Mexican cuisine, which is an Intangible Cultural Heritage of Humanity (UNESCO, 2010). It also reconnects local residents with the country's deep roots and rich culture around urban gardening, which goes back to the Aztecs and their chinampa system.

Socio-economic: The gardens offer spaces for migrants from rural communities to restore social connections. It is also a means to provide an additional source of nutrition for those with limited access to fresh, nutritious food.

Gender: Through the "Jardines para la vida: Mujeres polinizadoras" project approximately 400 women learned more about pollinators, the plants that are important for their survival, and the care they require.



An example of community gardening in Mexico City is the programme "Jardines para la vida: Mujeres polinizadoras": training women about pollinators and food systems [\[link\]](#)

3.2

PRAGUE



Prague is currently developing an updated circular economy (CE) plan (for release last quarter of 2021) that will endeavour to halve municipal solid waste by 2030 by enforcing a comprehensive set of measures on ambitious circular economy measures in the food, built environment, business, and waste management sectors. It will also build on an existing circular procurement initiative, explore the possibilities of local agriculture, and look into reduction of food waste.

This plan, like much of Prague's circularity strategy emanates from a multi-level approach starting with the European CE Strategy, the national strategy, and finally, city initiatives⁵⁸. The city has effectively rolled out multiple activities towards a circular economy, such as "Reuse Sundays", eliminating single use plastics in the city's offices and events, and building a state-of-the-art post separation facility for plastics, metals, and beverage cartons⁵⁹. Prague is a lesson on how cities can roll-out neighbourhood programmes based on a framework developed by local government.

Circular construction is a priority in Prague and its implementation has an impact on how neighbourhoods will be built but the implementation of circular construction in the city requires limited community engagement. Construction companies like Skanska are tasked to deal with recycling of materials after the deconstruction of buildings⁶⁰. The city also plans to start using slag, a by-product of incineration of municipal waste, as building material⁶¹.

In terms of servitisation, the Czech Republic already has one of the largest district heating networks in Europe⁶², thus facilitating circularity in the country's and Prague's energy system. The centralised production of thermal energy with district heating, enables highly efficient delivery of heating to different buildings/ households within a determined district. They have the potential to further improve efficiency and energy use via cogeneration (generation of both heating, cooling and electricity). District heating is the biggest in scope within the spectrum of Heating as a Service projects, which also have the potential to be implemented directly in individual dwellings when these are not served by district heating.

The city is also introducing circularity into the local food system by piloting efforts to reduce municipal food waste in three municipal districts (Prague 5, Prague 6, and Prague 7), with the ambition to replicate this city-wide by 2026⁶³. This government-led effort could be linked to the neighbourhood-driven development of community gardens in Prague. The first community garden was founded in Prague's Holešovice neighbourhood in 2012, and there are now approximately 60 of them throughout the city⁶⁴.

Prague's efforts in the three focus areas, while national/local government led, have a tangible impact at the neighbourhood scale. They are targeted towards communities and have a positive impact on the city's overall system. Prague's "neighbourhood approach" supports sustainability because they are incorporated into local regulation and adequately funded by the city government.

Prague RE-USE Hubs

The city of Prague consumes approximately 307,000 tonnes of consumer products each year. About 10% of it is considered bulky waste, materials too large for household waste and destined for landfills, such as electrical goods, appliances, and furniture. To address this, Prague is rolling out a decentralised network of circular 'hubs' – so called RE-USE Points – throughout the city. These facilities aim to circulate value in the waste that Prague's households produce each year, as well as to inspire and support circular lifestyles. The RE-USE Points serve as public facilities where citizens could leave items they would otherwise discard. The staff creates records of the items in the online app *Nevyhadzujto.cz* ("Do-Not-Throw-It-Out") where they are offered for free or symbolic price. The goal is to expand the network of RE-USE Points as a part of Prague's current waste collection system.

While originally conceptualized for consumer products the RE-USE hubs have evolved to include CDW. Construction companies can negotiate leases and support large de/construction projects, thus facilitating a transition to circular construction. There are currently three RE-USE points in operation in three different districts. During the first 8 months of operation, almost twenty tonnes of material were reused and diverted from landfills.

An example of initiatives facilitating the transition to circular construction is the RE-USE Hubs in Prague: construction companies can negotiate leases and support large de/construction projects [\[link\]](#)



3.3

STOCK-TAKING OF CIRCULAR ACTIVITIES IN CITIES AND NEIGHBOURHOODS

The table below summarizes the circular activities found in Mexico City and Prague, as well as a few snapshots from cities all over the world that helped shape the thinking on circular construction, servitisation, and neighbourhood food systems.

The list (not exhaustive) provides inspiration for other neighbourhoods that may want to incorporate circularity in climate or biodiversity action.

CIRCULAR CONSTRUCTION		
Mexico City	Prague	Global trends applicable at neighbourhood scale
Integration of construction and demolition waste into the built environment, example of the Sembrando Parques (Planting Parks) [link] or the Cuitláhuac Park [link] Signature of C40's Clean Construction Declaration, pledging to halve emissions from all construction activities in the city by 2030 [link] and updating existing regulation.	Development of new sustainable buildings and expansion of open space in former industrial zones, (e.g., Bubny-Zatory, Holešovice) [link]	Implement circular materials and design principles in the retrofit and new construction of buildings, such as using construction materials made from fungi in Kenya [link] Design of new buildings to prioritise longevity and adaptability, such as the design and construction of the Rwanda Institute for Conservation Agriculture (RICA) campus [link] Design for deconstruction of new buildings and interventions into existing buildings so they can be more easily reused in the future [link] Develop building passports - digital archives of materials of new and old buildings - to help build material banks [link]



3. WHAT CAN NEIGHBOURHOOD DO?

SERVITISATION

Mexico City	Prague	Global trends applicable at neighbourhood scale
Offering of solar power via power PPA, generating savings on household electricity bills of up to 50 per cent [link]	Retrofit of individual heating units into building-level centralized heating units, as the Czech Republic has one of the largest district heating networks in Europe [link]	CaaS at the building level (via the servitisation of A/C coupled with solar panels, circular water cooling) e.g., KAER Singapore [link] Residential Air Conditioning as a Service, such as the model applied by Baridi Inc in Tanzania [link] HaaS Green Energy in Germany with their virtual power plant [link] Comfort as a Service (combining CaaS and HaaS), such as the model applied by SECO Group in the UK [link] Servitisation of home appliances, such as the Washing Machines as a Service model applied by different companies in the Netherlands [Homie and Bundles]

FOOD

Mexico City	Prague	Global trends applicable at neighbourhood scale
Development of the Sembrando-Parque to expand existing public space network and embody key circularity concepts, such as ancestral agricultural practices (the "chinampas") [link] Development of "Gardens for Life: Pollinating Women": training women about pollinators and food systems [link] Creating pollinating gardens and green corridors in avenues crossing the City, through the "Green challenge" [link] Implementation of rooftop gardens for passive cooling (such as INFONAVIT) [link] Community markets such as the "Mercado de Trueque" and the "Mercado alternativo de Tlalpan" [link]	Collecting food scraps in 3 municipal districts (pilot project) with the goal to replicate this city-wide by 2026 and reduce waste at source. [link] Community gardens and homemade composting, supporting local biodiversity [link] Circular procurement principles applied on 500 ha of agricultural land owned by the city [link]	The People Parking Bay initiative in London that converts parking lots into green pockets [link] Populating road islands with indigenous food trees in Surabaya, Indonesia [link] Mapping food growing potential to increase community food production in the district of Lambeth, London [link]



4. CONCLUSION

4.1

WHAT CAN BE DONE AT THE NEIGHBOURHOOD SCALE?

By investigating the two case study cities through the lens of circular construction, servitisation, and neighbourhood food systems, this paper was able to map entry points for neighbourhood action in Figure 2 below, illustrating measures applicable to many contexts. The paper draws examples from Mexico City and Prague that showed that circularity is present in existing structures and that there are opportunities for communities to decouple themselves from linear systems.

Focus area	Potential impact	Neighbourhood action	
Circular construction	Promote local and community-led construction and repair.	Establish neighbourhoods material banks.	
		Invest in training of people in building repair.	
Servitisation	Generate critical mass demand for making the offering of products-as-a-service attractive to providers. Accelerate transition to renewables. Reduce overall energy demand with associated cost savings for households. Incentivise behavior change.	Transition to cooling, heating and other appliances as a service.	Collectively lease rooftops to solar energy companies.
		Explore decentralised energy options (solar PV and thermal).	Establish the use of shared facilities (e.g. laundry rooms).
Circular food systems	Strengthen environmental education. Reduce food waste.	Establish community gardens.	Supporting local food systems.
		Create links with peri-urban farmers.	Composting or create links with bio industrial facility.

Figure 1: Neighbourhood action and circularity

4. CONCLUSIONS

The historical roots for circular construction are present in both cities but needs to be reinforced by training and establishing mechanisms for the recovery of building materials. For servitisation, several innovative activities have already started, and it has the potential for rapid scale-up since the investment potential is already there. Neighbourhoods can provide the critical mass needed for making the offering of the service financially attractive to service providers at the household level. Community gardening appeared to be the easiest starting point for neighbourhoods but all three, this paper found, is doable at neighbourhood scale, with clear benefits in developing activities and investing at this level. The activities described in Figure 2 are tangible starting points for individuals, communities, and local businesses. They are manageable, even in areas with limited local government support.

Mexico City and Prague, however, showed that while neighbourhood action is an exciting starting point, local government investment was the essential element in the uptake and replication of circular initiatives in both cities. This is true even of the community gardening programme of Mexico City. While it was started by community non-profits, it flourished when the city allocated a budget for broader community engagement. Similarly, in Prague, local government leadership was the main driver behind neighbourhood-run RE-USE facilities⁶⁵.

Both cities also had plans in place to ensure that actions at the neighbourhood scale would be used to create bigger programmes (such as the case of community gardens in Mexico City) and to initiate change in an existing system (this in the case of the RE-USE facilities).



4.2

CREATING CIRCULAR NEIGHBOURHOODS

Making space for circular neighbourhoods through city action.

The experience of Mexico City and Prague tells us that there is a role for neighbourhoods in circular economy planning and implementation, but local government leadership is critical for sustainability. Many of the successful initiatives found were the result of deliberate city engagement with neighbourhoods to accelerate circularity.

In both cities, however, neighbourhoods are not systematically included as part of the strategic implementation of circular economy strategies, and this can only be changed through local level action. Incorporating neighbourhood-level action in urban planning and design processes could be achieved through participatory budgeting, public consultations for upcoming plans, and careful consideration of household consumption and waste in city strategies. Crowd-sourcing ideas of circular initiatives through a public call can also help identify action to replicate/upscale.

In addition to deliberate inclusion of neighbourhoods in the planning hierarchy, creating a local business environment that is friendly to circular initiatives can also help the private sector work with neighbourhoods, including the households and home-grown businesses in the communities. This was a clear opportunity in the servitisation space where government regulation on solar panels negatively impacted potential investments. On food systems, a city can support a centralised model for processing and selling of compost, linking households and businesses.

The potential value of mapping initiatives, resources, and actors (e.g. strong local businesses) to create inventories of neighbourhood actions towards circularity was also found in both cities. This inventory could be started by local governments and eventually serve as the basis from which cities could choose which community-initiated innovations to scale up in the future, or to identify which neighbourhoods to be supported.



The role of neighbourhoods

At the beginning of this discussion paper, this question was raised: What is the role of neighbourhoods in accelerating a circular economy transition? Beneath that was also the matter of whether or not neighbourhoods could be catalysts for a change in the urban built environment.

As the paper looked closely at the experiences of Mexico City and Prague, it found that governments, the private sector, and communities can initiate circularity in the built environment. Regardless of the origin of the intervention, reflecting on the circular economy at a neighbourhood scale made visible and tangible the possibilities of a shift towards circular economy. Circular construction triggered a reflection on both the past (vernacular architecture) and future (building codes), and how changing the way we build could potentially reduce the material footprint of cities. Opportunities for servitisation in Mexico City and Prague gave insight to how things could work differently in our homes towards a circular economy. A snapshot of neighbourhood food systems opened questions around the multiple benefits of community gardens – connecting us to nature and creating a shift in mindset towards circularity.

In cities, neighbourhoods are an opportunity to gradually address the critical challenge of the dependence on existing linear networks. By deconstructing cities into smaller action areas, it is possible to identify starting points for a radical transformation towards circularity. This scale allows for the design and operation of “living labs”. They are spaces that are large enough to be representative of community behaviour and their interactions with urban systems, yet also small enough not to be prohibitive in terms of costs and human resources⁶⁶.

It is in these spaces, these neighbourhoods, that inspiration can be found to reimagine, redesign, and rebuild the cities we live in.

ANNEX

Arup

Arup is an independent firm of designers, planners, engineers, consultants and technical specialists working across every aspect of today's built environment. From 90 offices in 38 countries, its 12,000 employees deliver innovative projects and help clients tackle their most complex challenges - turning exciting ideas into tangible reality and shaping a better world.

BASE

Established in 2001, BASE is a Swiss not-for-profit foundation and a Specialized Partner of the United Nations Environment Programme. BASE combines expertise in technology, markets, economics, finance and business development to deliver effective solutions for every project. BASE builds bridges between sectors and actors at the nexus between climate solutions, finance and international development, developing innovative ideas and tailored market-driven solutions for public and private organisations.

C40 Cities

C40 is a network of the world's megacities committed to addressing climate change, supporting cities to collaborate effectively, share knowledge and drive meaningful, measurable and sustainable action on climate change. Around the world, C40 Cities connects 97 of the world's greatest cities, representing 700+ million citizens, and one quarter of the global economy, to take bold climate action, leading the way towards a healthier and more sustainable future. C40's mission is to halve the collective carbon emissions of member cities within a decade, while improving resilience and equity and creating the conditions for everyone, everywhere to thrive, by identifying the world's climate best practises rapidly replicate them all around the world.

Ellen MacArthur Foundation

The Ellen MacArthur Foundation develops and promotes the idea of a circular economy. The Foundation works with, and inspires, business, academia, policymakers, and institutions to mobilise systems solutions at scale, globally. It aims to accelerate the transition to a new economic system that delivers better outcomes for people and the environment, by promoting business models, products, and materials that are designed to increase use and reuse, replicating the balance of the natural world, where nothing becomes waste and everything has value.

MASS Design Group

MASSDesign researches, builds, and advocates for architecture that promotes justice and human dignity. They are a team of over 140+ architects, landscape architects, engineers, builders, furniture designers, writers, filmmakers, and researchers representing 20 countries across the globe, who believe in expanding access to design that is purposeful, healing, and hopeful. Their projects move beyond just issues of energy use and efficiency, to holistically design the project ecosystem, including an entire supply chain that is sustainable, resilient, and regenerative. MASSDesign's work has been featured in over 4,000 publications.

IPR Prague

The Prague Institute of Planning and Development (IPR Prague) is the body in charge of developing the concept behind the city's architecture, urbanism, development and formation. It is an organisation funded by Prague and represents the city in spatial planning matters. They have been instrumental in drafting the Prague Building Regulations, the Prague Waterfront Concept, the Prague Public Space Design Manual, the metropolitan land use plan for Prague, and the implementation of the Prague Strategic Plan. IPR Prague also processes geographical data and information for the city.

SEDEMA Mexico City

The Ministry of the Environment is working on an agenda focused on five priority areas to protect the environment and promote sustainable environmental development, with clear goals and actions for the integral and efficient use of natural capital and a new environmental governance that allows us to invest in, maintain and manage our natural resources.

SEDUVI Mexico City

The mission of the Ministry of Urban Development and Housing is to generate and integrate an urban and housing public policy for territorial cohesion and that contributes to the sustainable development of Mexico City. Its vision is to have a Ministry that contributes to ensure territorial justice and social inclusion, by innovating the system of planning and public management of urban development and contributing to the protection of the human right to housing, in congruence with the territorial planning of Mexico City.

UNEP

UNEP is the leading environmental authority in the United Nations system. UNEP uses its expertise to strengthen environmental standards and practices while helping implement environmental obligations at the local, country, regional and global levels. UNEP's mission is to provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations.

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- ⁵⁰ Hand, K. L., Freeman, C., Seddon, P. J., Recio, M. R., Stein, A., & van Heezik, Y. (2017). The importance of urban gardens in supporting children's biophilia. *Proceedings of the National Academy of Sciences*, 114(2), 274–279; Dunnett, N., & Qasim, M. (2000). Perceived benefits to human well-being of urban gardens. *HortTechnology*, 10(1), 40–45.
- ⁵¹ City of Mexico, Head of Government Office (2020) Inauguran Gobierno de México y capitalino Primera Etapa del Parque Cuitláhuac en Iztapalapa. [\[link\]](#)
- ⁵² Moreno, P. (2020) State of Play for Circular Built Environment in Latin America. One Planet Network. [\[link\]](#)
- ⁵³ Terra Energy (n.d.) Preguntas frecuentes: Cuánto y cómo ahorro? [\[link\]](#)
- ⁵⁴ SEDEMA (n.d.) Mercado de Trueque Statistics. [\[link\]](#)
- ⁵⁵ Thelmadatter, L. (2020) From floating islands to abandoned lots: urban gardening in Mexico. *Mexico News Daily*. [\[link\]](#)
- ⁵⁶ City of Mexico (2019) Inventario De Residuos Sólidos De La Ciudad De México. [\[link\]](#)
- ⁵⁷ FAO (2015) Urban and Peri-urban Agriculture in Latin America and Caribbean: Mexico City. Growing Greener Cities. [\[link\]](#); Dieleman, H. (2017). Urban agriculture in Mexico City; balancing between ecological, economic, social and symbolic value. *Journal of Cleaner Production*, 163, S156–S163.
- ⁵⁸ Prague has prepared several documents to outline and articulate its Circular Economy Plan. As part of its climate neutrality plan, Prague has defined circular economy as one of the four key pillars to achieve net zero by 2050. Prague has also started an expert Steering Committee for Circular Economy which directly advises the city council on the most systemic solutions. In May 2020, Prague commissioned the elaboration of the Strategy for the Transition of the Capital City of Prague to a Circular Economy, and the city updated the regional and municipal waste management plan. The Strategy builds on the Circle Scan Prague prepared by Circle Economy and INCIEN based on the collaborative Circle City Scan process, which highlighted the potential to promote circular lifestyles in RE-USE Hubs/Points, using public procurement, to boost circular construction, and to use the city's food waste as bio-

methane to power the city's waste collection fleet. The city is also developing a comprehensive strategy (to be released last quarter of 2021) again together with Circle Economy, which covers a wide range of areas including construction and circular food systems.

⁵⁹ World Economic Forum (2021) Prague: The Circular European Capital You Haven't Heard of Yet [\[link\]](#)

⁶⁰ CZGBC (n.d.) The construction industry produces two thirds of the waste in the Czech Republic, while some building materials are already running out. [\[link\]](#)

⁶¹ Annually, incineration produces 65 to 75,000 tons of slag

⁶² Pražská teplárenská (2009) Prague District Heating System: Application for 1st Global District Energy Climate Awards. [\[link\]](#)

⁶³ City of Prague (n.d.) GASTROodpad. [\[link\]](#)

⁶⁴ Prague Morning (2021) The Rising Popularity of Community Gardens in Prague. [\[link\]](#)

⁶⁵ This programme emanated from the Circle Economy, INCIEN, and Prague government-led Circle Scan process

⁶⁶ Cuomo, F. et. al. (2020). Transformative urban living labs: Towards a circular economy in Amsterdam and Turin. Sustainability (Switzerland), 12(18), 1–19; Amenta, L. et. al. (2019). Managing the transition towards circular metabolism: Living labs as a co-creation approach. SSOAR-Social Science Open Access Repository.

