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Food Security and Circular Cities: Paradigmatic Shifts, Geographical and Temporal Scales, and Participatory Governance Support to Facilitate Transitions Towards 'Urban Sustainability'

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Abstract: This article explores how the principles of circularity, applied to urban food systems, could contribute to catalysing a transition towards more sustainable cities, working on the premise that food security is a key pillar of urban resilience. In order to do so, it critically examines i) circularity in the context of urban regeneration and why focusing on food could help to understand the socio-political and ecological dimensions of circularity; ii) the geographical and temporal scales of urban circularity and iii) how 'barometers of circularity' could be built and integrated into participatory urban governance processes to support urban ecological transformations.

Keywords: circular food systems; circular cities; participatory urban governance; urban ecosystems; barometer of circularity; transition to sustainability

1. Introduction

The un-sustainability of our cities has been generating concerns for a while. Statistics on cities [1] reveal that, despite occupying 2% of the land, cities generate nearly 70% of CO2 emissions, produce an enormous amount of waste (60%) and pollution and use 80% of energy. The New Urban Agenda, announced at Habitat III in response to Sustainable Development Goal (SDG)-11, has called for a new paradigm on which to base a reform of our governance systems so that sustainable urban and territorial development can be integrated as essential components in the achievement of sustainable development [2].

In this article, we suggest that such new paradigm could build on insights from research on 'circularity'. Focusing on waste and on the inefficiency in natural resource management as main 'urban problems' is indeed an imperative. Cities do need to reduce the magnitude of their 'ecological footprint' – which, as [3] explains, "is the amount of land required to support people's lives and lifestyles which, ideally, should not exceed the productive land on earth. The richer the city, the more it tends to draw on nature's bounty from across the world rather than its own local hinterland" [3] (p.86). As our populations grow and global consumption increases, cities' ecological footprints have been forecast to triple over the years to 2030 whilst a third of the food we produce is currently being wasted. It is essential that we envisage new ways of meeting our needs.

The principle of a Circular Economy (CE) [4] is that the economy, so far based on the linear principles of use-produce-throw away, could be transformed so that it reduces waste to possibly zero, uses renewable energy and adds value to by-products. Attempting to make a city circular works on the same basis. However, this seemingly quite straightforward reduction and re-use of waste generates all sorts of socio-cultural, ecological and political implications in terms of urban governance and transformation. For [5], CE encourages us to completely re-imagine a 'well-performing city' as a system that provides residents with their basic needs for water, food, energy and shelter in an efficient way. In such context, 'indicators of success' would therefore not only shift to a zero-waste type of urban development but would also reflect the enhanced level of responsibility for the local

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environment, and of infrastructure support taken by urban communities. Although research on CE has approached the challenge of minimising cities' waste in various ways – for instance through life cycle analysis, cradle to cradle techniques, industrial ecology or new business models [4] -, CE principles in fact go well beyond reducing and re-using waste, and adding value to by-products. In order to apprehend better the fuller potential of circularity, this article undertakes a critical exploration of three of its particularly relevant aspects in the context of urban transformation toward sustainability, advocating an interdisciplinary, participative and ecologically regenerative approach, itself catalysed by an urgent concern - that of urban food security.

First, it explains how focusing on the urban food system, as a practical point of departure from which to build circularity, could be particularly relevant: these have been shown to be core to urban resilience and, besides, the operationalisation of circularity principles will need to be incremental, with a strategic starting point. Working on such practical 'case study' will highlight the need for a critical discussion on the disciplinary-paradigmatic boundary of CE. Secondly, the centrality of the food system in the context of urban circularity encourages a discussion on the geographical scale at which such circularity is being designed, critically questioning both (too) small scale preferences for sustainable food production and globalised food trade. The incremental and participatory nature of urban transitions towards more resilience and circularity, in turn, simulates a discussion on temporal considerations in CE. Thirdly, since CE principles fundamentally question the linear processes on which economic activities rely in view of pursuing economic growth, the article concludes on the urgent need to reform indicators of 'economic success'. The third part therefore presents alternative barometers of circularity, emphasising the need to apprehend circularity within the context of an ecological-economic urban ecosystem. It highlights how participatory circular food systems (CFS) could act as a catalyst to create participatory urban governance processes at the level of urban activities.

2. Urban Circularity: A Paradigmatic Dialogue Between Theories and Needs

This section explores why a focus on food and CFS could help us to apprehend urban circularity through a new paradigmatic lens, better adapted to the cities of the future's needs.

2.1. Circularity in the Context of Urban Transformation and Regenerative Development

Making cities more circular has often been regarded as a pre-requisite for making them more sustainable. For [6], it is "taking a circular approach to development [that] will enable the resource-efficient, waste-free, ecologically regenerative and continual renewal of the city" [6] (p.8). In turn, making cities more circular could generate, as the title of her book stresses, a 'revolution in urban sustainability'.

The notion of circularity is most often linked to the need to minimise or eliminate waste in view of both making our resource management more efficient but also of addressing the 'waste' problem, which, in the case of cities, is dramatically urgent. For long, 'circularity' has been approached from an industrial ecology (defined by [7] as a study aimed at understanding the circulation of materials and energy flows) or from a business model perspective [8] define a circular business model as one which facilitates the creation of added value by re-using the economic value retained in products in the creation of new products or services).

In this paper, we suggest to explore circularity from an urban development perspective and to use it to facilitate urban transformations towards more sustainability and resilience – considering a sustainable city as a self-sufficient economic, social and environmental system [9] and a resilient one as a city that is prepared for un-certain futures [10].

Suggesting such a critical paradigmatic reflection on the notion of circularity is aimed at addressing a few important gaps identified by researchers in CE but also to un-lock a research situation somehow paralysed by the number of interactions to be taken into consideration in order to 'close the loop' of a CE. The complexity is so daunting that it is difficult to know where to start to 'circularise' the interactions between all urban activities.

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The 'gaps' mentioned by [11] and [12], in particular, highlight a lack of social dimensions, not enough importance given to consumption (a major focus being put instead on the production and provision of goods), but also to the context within which CE is to be operationalised. [11] stresses the fact that because circular activities, products and services are under-valued by the market, it is difficult to make them compete with existing systems of provision. She therefore recommends moving away from an economic, market-centred, approach to circularity and to investigate, instead, a developmental approach to it. As she explains, "Circular Development (CD) territorialises circularity (considering both context and scale) and its impacts on urban systems, activities and infrastructure. It incorporates social dimensions, recognising the impacts of CD on society (and vice versa). It integrates political dimensions, recognising the important role governments, industry, business and communities play in delivery" [11] (p.15). If CD responds to some of the shortcomings of CE when applied to cities, we suggest that the concepts of 'urban metabolism' and 'Urban Ecosystems Functions' (UEF), could also help to integrate ecological dimensions into 'urban circularity'. Thus, in addition to the prime notion of waste taken into account in circularity principles, we suggest to also address the damage caused to the life support ecological basis we depend upon as a form of 'negative by-product of our activities'. This directly connects the notion of circularity to that of 'regenerative development' – focused on the linkages between city people and nature, between urban systems and ecosystems [13]. [14], who stressed the fact that the impacts of CE are too often linked with economic prosperity and less with sustainable development, also advocate to "go beyond the economic understanding of the topic, and to assume a systemic perspective that combines CE and urban metabolism, including a plurality of stakeholders, including not only resources but also culture and society" [14] (p.75). In line with this, an ecological-economy paradigm would provide a helpful alternative to develop new production and consumption chains and networks, the rise of complex networks and the value-added to rural and regional places [15]. To illustrate how CD could be enhanced by the notion of regenerative development and ecological-economics, we focus next on the study of urban CFS as core to urban sustainability and resilience.

2.2. Circular Food Systems: A Practical Starting Point to Operationalise Urban Circularity

This paragraph focuses on the 'where to start?' (when trying to make a city circular). Here, we explore how making the food system circular could act as a key catalyst for sustainable change in an urban context, working from the following key points:

1) Urban food production is connected to many aspects of urban activities and dimensions and therefore can have a large impact (through interconnections). Such interconnections were, for instance, illustrated through the integrated approach developed by [16], who extended CE principles in food systems[1] transformation to address human, environmental and economic health. As [17] explain, "Food is an interconnected urban infrastructure that has to be designed and managed in a circular way" [17] (p.5) through policies that put food at the core of a new series of change that will provoke a domino effect of sustainable solutions. Improving urban food systems (FS) as catalysts of urban transformation towards more resilience facilitates the integration of ecological and social dimensions in CE, thanks to the systemic nature of food.

2) In addition, food is one of the most important human basic needs, which happened to have been un-met or 'in crisis' during the COVID pandemic. In this context, [18] analysed the impact of Covid-19 on food security and nutrition and the various lessons learnt are drawing attention to the centrality of food in urban transitions. Attempting to make cities more sustainable must therefore

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[1] *'Food systems', as defined by Ericksen (2008), include the full value chain of producing food for human consumption, from agricultural production, through transportation, handling, processing, storage, distribution and consumption, to waste management and disposal. (Ericksen, P. J. (2008). Conceptualizing food systems for global environmental change research. Global Environmental Change 18 (1), 234–245. https://doi.org/10.1016/j.gloenvcha.2007.09.002)*

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also take account of the fact that jeopardising food security is symptomatic of a failing economic system: as [19] conclude in their policy recommendations, research on urban food security needs to evolve towards a more holistic sustainability policy discourse and urban food security may be better positioned from a sustainable urban development lens rather than an agricultural lens. This illustrates a growing link between the fields of urban food security and sustainable urban development. The sustainability and resilience of an urban environment is therefore closely linked to the resilience of FS, defined by [20] as the capacity over time of a FS and its units at multiple levels, to provide sufficient, appropriate and accessible food to all, in the face of various and unforeseen disturbances.

3) As [21] highlighted, food is also one of the biggest contributor to climate change. At national levels, states still use food production to feed economic growth in a linear way, making food a priority to tackle if we are to change our modes of production.

4) The urban scale is also critical since 80% of food demand comes from cities. We therefore need to re-think how we produce the food we need. Both the Covid pandemic and the food and fuel price hikes of 2007-2008 triggered a re-orientation of agri-food, which stimulated the development of alternative economy models and, at their centre, the redefinition of agriculture articulated around sustainability, sovereignty, security and governance.

The question we next address is how to critically build on existing examples in order to provide a fuller approach to CFS that triggers transformation towards urban sustainability.

2.3. Examples of Circular Food Systems

Numerous initiatives have already been undertaken to make urban FS more circular. The literature on such initiatives focuses on 'eco-innovative solutions' (EIS) of all sorts. In particular, "EIS for waste aims to innovate processes in relation to the management of waste as a resource" [22] (p.12). Such EIS can refer to the innovations related to urban agriculture (UA) - much needed due to limited urban space.

The literature shows many examples of CFS focused on the creation of innovation food hubs. Thus, [5] advocates the creation of CE innovation Hubs that would facilitate the integration of water, energy, food and built systems and which, through their connection in a network, would enable various stakeholders to collaborate to re-purpose waste. They suggested that innovation hubs could thus be imagined as "co-working spaces as well as low-cost platforms for innovators and entrepreneurs" [5] (p.91). [14] suggest to link innovation hubs to the creation of resilience corridors able to connect different parts of the city (urban and peri-urban; historic downtown and peripheral areas, etc.; the economic centres to the satellite areas) in view of guiding a transition towards the creation of regenerative cities. [16] also give examples of food hubs as place-based food organisations (e.g. Food Exeter and Bristol food network) which develop a collaborative approach to create new routes to market that enable small-scale local food producers to access new consumers and provide physical space for community practices.

The design of such regenerative food systems follows the principles of i) closing loops (using renewable energies, returning biological nutrients into natural cycles, and re-using materials); ii) celebrating diversity and cooperation through community supported agriculture (a decolonialisation process which helps communities to take charge of food production); iii) generating 'place-based value retention' (as alternatives to linear agri-food models dominated by large producers and retailers).

Exploring the specific aspects of urban agriculture (UA) that can be used to implement urban circularity has been carried out by various researchers. [23] explore how various types of waste (waste water, organic waste transformed into compost, reclaimed building materials, etc.) could be used in a plethora of circular UA projects parts of the COST Action programme CA17133, emphasising the particularly circular nature of UA (which systemically links water energy and waste). [24], in turn, also talk of various types of innovation related to UA. These include social innovation (e.g. community roof top gardens or social cooperative farms, with 'community managed activity towards

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community building', or 'local and organic production creating inclusive jobs'). The authors also explore technological innovations (examples include high tech-greenhouses, indoor farming, or open-air rooftop gardens, including the use of protected soil-less production with integrated heat and water recirculation, resource-efficient LED production). The economic dimensions in UA innovations include new business models, and closer interactions and solidarity in economic practices.

[4] is now putting great hopes in the ability of cities to "play an important role in sparking a shift to a fundamentally different food system in which we move beyond reducing avoidable food waste to designing out the concept of 'waste'" [4] (p.10). In line with the European Bio-economy Strategy [25], which supports CE activities related to nutrient looping, industrial strategy, and climate policy, the EMF emphasises that "achieving these ambitions would allow cities to move from passive consumers to active catalysts of change, and generate numerous benefits" [25] (p.12) – including financial savings, reducing annual greenhouse gas emissions, avoiding the degradation of millions of hectares of arable land per year, creating new jobs, and improving human health.

3. Circular Food Systems: A Reflection on Geographical and Temporal Scales

In this section, we explore the geographical and temporal scales at which CFS could take place. One important contribution of circularity has been to trigger a reflection on what defines wastes. Questioning the 'boundaries' that separate waste from valuable resources has, in turn, shaken the boundaries and scales of CFS and food security, both in spatial and temporal terms.

[26] describes waste as "what is worthless or unused for human purpose: it is a lessening of something without an apparently useful result" [26] (p.50). Extending the definition, [27] adds that "there are waste things, waste lands, waste time, and wasted lives" [27] (p.146), highlighting the spatial, temporal – and even ideological dimensions of the concept. [28] deepened her reflection on waste in an urban context, extending it to the notion of 'waste landscape' defined both as actual waste (e.g. municipal solid waste, sewage), wasted places (e.g. abandoned and/or contaminated sites), or wasteful places (e.g. parking lots): waste landscapes [29] can thus be synthesised as 'wastescapes' – a holistic concept that includes scales regarding material circularity but also territorial dimensions, [and that encompasses] spaces for opportunities to develop sustainable urban regeneration. As residual spaces, wastescapes are therefore of particular relevance in CD since such waste needs to be transformed, 're-invented', bringing wastescapes at the centre of the urban transition debate. Peri-urban areas can represent such vulnerable territories. As transition zones from urban to rural, they display chaotic sprawl and are often at the core of where socio-economic changes and spatial reorganization occur.

The 'transitioning' motivated by a re-definition of wastes and by extending the geography of circularity, also extends to temporal considerations since the transformation of wastescapes, for instance, is at the very core of the long-term transition towards urban sustainability triggered. Both geographical and temporal scales therefore need to be taken into consideration.

3.1. Reflection on the Geography of (Urban) CFS

This section critically explores the boundary of the 'circular city' when it comes to waste management, food production and food security.

3.1.1. Using the Inner-City Space Efficiently – 'Localising CFS'

We mentioned earlier the relevance of the city scale in the context of a reflection on circularity and food security. This focus on (and preference for) the local scale was largely motivated by the fact that "Global food systems dynamics have been recognised as major contributors to the degradation of ecosystems, the generation of GHG emission and public health concerns" [4]. Some European cities have started to design urban food strategies (e.g. Milan, London, Malmö, Ghent, Vitoria, Lisbon) [30,31]. Altogether, such strategies in metropolitan areas have recently highlighted "the need to re-localize production–consumption systems through shorter, more efficient supply

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chains, as a means of promoting sustainable urban development via place-based approaches" [32] (p.9) and to improve the local ecosystem's health.

Such efficiency can derive from small-scale agriculture based on permaculature, agro-forestry or more generally agro-ecological methods. [33] demonstrated that small-scale agriculture in fact generates higher yields than extensive industrial agriculture whilst [34] are investigating how agro-ecology, which currently provides 15 to 20% of global food, could help cities reach a state of food self-sufficiency. Various attempts to 'sustainably intensify' agriculture [15] acknowledge the need to try to get more from less land surface, especially in cities.

Localising urban FS has also been done through the exploration of various types of Short Food Supply Chains (SFSC), whose main characteristic is its "capacity to re-spatialize food, thereby allowing consumers to make value-judgements about the relative desirability of foods on the basis of their own knowledge, culture and experience" [35] (p.3). SFSC allows considerable reductions in CO2 emissions and saves energy from un-necessary transport. If food in the United Kingdom was produced and consumed locally, the level of CO2 would be reduced by 22% [36]. The 'distance-saving' is also social since SFSC "enables the redefinition (and valuing) of the relationships between producer and consumers, showing the origin of food" [35] (p.3).

In addition to the efficiency motive associated to focusing UA to the local scale, [15] emphasise the fact that a more place-based eco-economic model is needed if synergies between sustainability, security, sovereignty and effective resource governance are to be reached, relying upon the agency and power of place in new and innovative ways. In effect, eco-effective entrepreneurship (which regenerates maximum added value by redesigning processes so that every output can be an input for a next product) needs to be localised and based, as [37] explains, on the 'action-habitat' notion – i.e. "the area for which people feel responsible and the reciprocal movements it generates since the care for the well-being of a city goes hand in hand with the care given to a neighbourhood" [37] (p.39).

The focus on (and predilection for) the local level, in the examples of food production and circularity given earlier, deserves however a careful critical questioning in the light of what has been designed by [38] as 'the local trap' – i.e. the assumption that 'local' is inherently good and that a local food system will be more just than a national or a global one. Applying a critical geography approach to UA, [39] pointed to the fact that it is not so much the local scale that matters in UA but, rather, the role that UA can or should play in the current restructuring and rescaling of urban ecological security and in the geopolitical configurations between cities and countries. The problem is to treat the local scale as an end in itself rather than a means to an end (e.g. sustainability). Adopting a critical geography of UA is therefore needed to unveil how issues of socio-environmental justice are embedded in UA as a form of place-making and to systematically explore the spatial opportunity for a radical re-making of the urban environment. To do so, the notion of scale, described by [38] as a socially produced strategy, is particularly insightful. As the authors emphasise, local food systems can be sustainable or not, depending on the particular practices that agents pursue. They show that the same is true of global systems by explaining that "one important scaler strategy through which firms have pursued the capitalisation of agriculture has been globalisation: food production, supply chains and food markets have become increasingly global as a means to achieve capitalisation" [38] (p.199). Normative research should therefore focus on analysing why a particular scaler strategy is better than another for achieving specific goals, bearing in mind that scale is not permanent (e.g. the dominance of national-scale state is waning with, on the one hand, many governing functions being transferred to large scale bodies –e.g. EU or UN - and, on the other hand, other state functions being devolved to local scales) and that scale is also relational (to other scales). If, as we explained earlier, our objective is to explore how CFS could help cities to become more sustainable, then working with scale is particularly useful in that it helps to explain why urban CFS should extend to the periphery and also why, in view of pursuing food security and urban resilience in the broader context of food democracy and sovereignty, the geography of CFS in fact also extends to international networks.

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3.1.2. Extending the CFS to the Periphery

Aimed at improving food security and facilitating transitions to more sustainable and resilient cities, the creation of CFS aligns with 'food movements' which, born in the United States, emerged from a food insecure system that had become dependent on agro-industry, with a high impact on health [40]. Through a process of re-spatialisation of food systems, "a new interest for re-integrating agriculture into urban areas has emerged in Western cities" [41] (p.2). In practice, this meant that many UA initiatives emerged within the city. However, peri-urban agriculture also attracted interests, especially in the context of fast and uncontrolled urban expansion. As [22] (p.11) stress, "urban expansion is expected to take place on soils of relatively high agricultural productivity (deltas, river valleys…) until 2030. In response to the urgency to declare a global restriction against urban encroachment on high quality soils (…) circularity processes could contribute to regenerate wastescapes such as peri-urban areas" (within 20km of cities) which, as [4] explains, already hold 40% of the world's cropland.

[36] worked through various scenarios (illustrating the use of dis-used land within the city as well as in the periphery) to show that a city like Cleveland could cover 100% of its food needs. Studies have also been carried out in Europe (Rome, Paris, …) to investigate whether various cities could cover their food needs if food started to be approached through a spatial planning lens or as an innovative dimension of territorial policy, progressively generating tighter cooperation amongst stakeholders [42]. This illustrates the fact that the geographical scale covering food activities aimed at contributing to urban transition actually enlarges the boundaries of the city itself to the city-region - a territorially integrated node of socio-spatial architecture to configure rural-urban linkages – [43] and the 'city-region food system' [44].

The extended boundaries, as we will see later, also reflect the various urban ecosystem functions that the urban food system contributes to, extending beyond the city centre to the city's periphery.

3.1.3. Urban Food Security, Food Democracy and Alternative Food Networks

As [35] explain, the concept of SFSC emerged at the turn of the century in the context of the broader debate on 'Alternative food chains' and 'Alternative food networks' (AFN). Since then, a new type of producer–consumer cooperation in food networks has emerged which question the dominant globalization and concentration trends in food markets.

These AFNs [45] "represent a shift in the role of consumers from passive end-users of food products towards more proactive 'citizen–consumers' who intend to regain control over the ways in which their food is produced and provided" [45] (p.290). They encompass new types of food production processes "in which voluntary, associational principles and participatory forms of self-management are paramount, suggesting the need for a revaluation of the role of civil society-driven governance mechanisms as a source of innovation and transformation of agri-food systems" [45] (p.291). Initiatives of this type are increasingly emerging at the local level, particularly in industrialised countries, where municipal governments are recasting themselves as food system innovators. However their impact at a more global level is also important since they respond to a 'new geography of food security' [45] which places localised circular food systems at its core, contributing to the emergence of better global food democracy – a situation in which, as [46] explains, "all members of an agro-food system have an equal and effective opportunity for participating in shaping that system, as well as knowledge about the relevant alternative ways of designing and operating that system" [46] (p.83).

3.2. Reflection on the Temporal Scale of CFS

Finding ways of re-using or eliminating waste and by-products in view of promoting circularity in the production of goods and services that meet urban citizens' needs requires innovative processes, cooperation amongst stakeholders, potentially new regulations, and new governance systems with an overview of the 'state of improvement' – or success – to be achieved. Operationalising such a

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transition movement towards sustainability is going to require, above all, time. Thus, for instance, time will be needed for "the learning obtained by key stakeholder engagement in the CD process [to] result in the scaling-up of projects or translation of circular practices and infrastructure to new locations" [11] (p.32). Temporal considerations are essential when discussing and negotiating the social integration of technical inventions (i.e. innovation) that would help to minimise waste.

Whilst EIS for CFS can be enhanced through new forms of urban planning in which innovative forms of development can emerge [11] (p.27), knowledge sharing on such innovations can also take place through broader networks (e.g. the Urban Green Train [30] and the FoodLink [42] projects). As [6] stresses, such networks of learning can facilitate the transformation over time of urban systems, since "the adaptive capacity of a city is underpinned by the potential for the urban community to self-organise and learn and for the socio-technical systems to co-evolve" [6] (p.4). Such form of dynamic adaptive governance [47] is designed to allow for and use disturbance to build knowledge to increase resilience and the capacity for responding to future uncertainty (such as climate change). It requires the ongoing iterative process of policy monitoring and the involvement of stakeholders in creating these policies through collaboration, including with non-governmental bodies.

In all cases, new temporal dimensions don't only relate to the time needed for stakeholders to learn from each other and for innovations and new practices to be integrated in society; they also reflect the temporal scales at play in ecological processes such as those in agricultural production. A temporal re-adjustment of ecological and economic functioning is therefore needed if circular transitions are to encourage better socio-ecological-economic interrelations.

4. Transitioning Towards Sustainable Cities Using Circularity: How (Using Which Decision-Making Tool)? With Whom?

Actions need to be coordinated in a circular city. Transforming cities into circular ones necessarily requires understanding better the type of waste that is being generated, by whom, in which quantity, and how it could be re-used, recycled, or added value to. Often, approaches towards circularity are reduced to technical eco-innovations. An an input-output/ material flow type of overall (albeit quite complex) tool can, for instance, help in re-allocating misplaced 'undesirables'. However, as explained earlier, the objective of transforming a city into a more circular one in view of increasing its resilience and of involving its citizens in its transformation goes beyond this technical 're-distribution exercise'. This section offers two interconnected ways of addressing the question of which type of 'barometers of circularity' can be built, and who would be using them? The first one is to integrate circularity in the context of the city viewed as an ecosystem. Using circularity as a barometer to facilitate sustainability transitions here therefore means respecting circular regenerative production loops whilst protecting urban ecosystems functions. The second sub-section discusses how participatory urban governance processes can use the framework presented above in order to help make FS circular.

4.1. A systemic 'Barometer of Circularity'

Here, we suggest representing the city as a socio-ecological-economic ecosystem which delivers various types of functions, as opposed to only consumption goods. This approach builds on work on System of Environmental and Economic Accounts –Experimental Ecosystems Accounts (SEEA-EEA) aimed at improving economic performance whilst protecting ecosystem services [49]. It however differs from it in that it does not advocate building ecosystems *in parallel to* economic account but considers the *city itself* as "an urban ecosystem in which resources are consumed and waste is produced from a myriad of activities" [6] (p.8). As [26] explains, "through the lens of CE, cities are equated to ecological-economic systems and are related to the metabolic flows of their local economies" [26] (p.47). Urban activities therefore contribute to delivering and protecting urban ecosystemic functions (UEF) – understood as including Production (provision of raw materials that become food, fuel, etc.), Habitat (a liveable place for human communities), Regulation (of major

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cycles – including ecological such as carbon and water) and Amenity (contributing to human welfare) functions [49]. Focusing in such as way on understanding the dynamic interactions between nature and society and on addressing the normative question of how coupled human-environment systems would function aligns with what [15] describe as 'post-normal sustainability science', approaching the city as an 'urban metabolism' – that is: "the sum total of the technical and socioeconomic processes that occur in cities, resulting in growth, production of energy, and elimination of waste" [14] (p.73). Adopting circular approaches is going to make us "face the key challenge of selecting approaches to urban design and materials and production methods that comply with natural ecosystem laws" [13] (p.8).

At the city level, this means that a completely new integrated science of urban planning is needed, with decision-making tools that reflect this. Table 1 illustrates how we can start approaching the city as an ecosystem by observing how UA activities contribute to all UEFs. Building on this, we can now explore in more detail what forms of capital are needed for people to be able to carry out UA activities. These can be of an ecological basis (e.g. water or soil), but forms of capital also include technologies (e.g. hydroponic farms), human capital (with people being trained for new types of jobs in UA), cultural capital (e.g. social learning taking place in allotment gardens and cultural mixes), and financial capital (e.g. potential subventions). A sustainable use of capital will pay particular attention to whether the type of capital can be substitutable. Critical Natural Capital cannot be replaced and, since it is responsible for the delivery of important ecosystems functions, must be protected as much as the functions themselves.

Table 1. Goods and services delivered by urban agriculture activities through ecosystems functions (compiled by the author).

Production functions	Food, biomass,…	Provision of local food Increase in food security
Habitat functions	Buildings	New adapted spaces for UA
	Private and public space	Green corridors
	Transport infrastructures/ connections	Social & cultural mix/ Alternative Food Networks
Information functions	Health services	Biological healthy food
	Education services	Agro-ecological activities as a teaching resource
	Recreation, culture, tourism	Walks and fruit-picking 'tours'; Improved local image, place branding
	Training for new jobs	Training sessions
	New laws and regulations	Healthy food production
	Legal measures/ subsidies/ funding	Promotion of land use for UA
Regulation functions Sink functions	CO_2 absorption	Growing vegetation absorbs more CO_2
	Waste and water recovery/ re-use	Waste water re-use for irrigation
	Nutrients recovery and reuse	Re-use to enhance productivity
	Energy recovery and reuse	Energy saved through limited transport
	Building materials recovery/ re-use	Building material for parks, greenhouse…
	Building/ land recovery	Reconverted land for green corridors
	Compost made with Organic waste	Compost used in large quantity
	Reduction of soil erosion	Increasing soil fertility; carbon storage in soils
Regulation functions Life support functions	Restoring/ protecting water cycles	Reed cultivation to absorb floods; Groundwater recharge; storm water retention;
	Regulation of temperature in city	Create shade and cooling
	Biodiversity protection	Varied species planted/ enhance pollination -e.g. through urban bee keeping
	Landscape ecology	Green corridors
	Governance of the urban ecosystem's circularity	New jobs in UA, landscape ecology Facilitators for negotiations and governance

Attempting to operationalise strong sustainability can therefore be achieved by both maintaining UEFs and maintaining the capacity of the capital stock to provide those functions [49], using information such as that provided in Table 2.

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Table 2. The use of capital forms by FS activities to contribute to UE functions. (compiled by the author).

Standards Targets , RC Restrictions on capital use	Type of Capital C needed in Food System activities	FSA1 Production	FSA2 Distribution	FSA3 Processing	FSA4 Education	FSA5 Food waste manag't	total capital use for UEF 1	FSA1 Production	FSA2 Distribution	FSA3 Processing	FSA4 Education	FSA5 Food waste manag't	total capital use for UEF 2	FSA1 Production	FSA2 Distribution	FSA3 Processing	FSA4 Education	FSA5 Food waste manag't	total capital use for UEF 3	FSA1 Production	FSA2 Distribution	FSA3 Processing	FSA4 Education	FSA5 Food waste manag't	total capital use for UEF 4	Total type of capital used TCn in the LMA food system activities to contribute to urban eco-systems functions
RC 1	C1 water						tC1 UEF1						tC1 UEF2						tC1 UEF3						tC1 UEF4	TC1 = sum of tC1 $UEF_{1,2,3,4}$
RC 2	C2 seeds						tC2 UEF1						tC2 UEF2						tC2 UEF3						tC2 UEF4	TC2 = sum of tC1 $UEF_{1,2,3,4}$
RC 3	C3 soil						tC3 UEF1						tC3 UEF2						tC3 UEF3						tC3 UEF4	TC3 = sum of tC1 $UEF_{1,2,3,4}$
RC 4	C4 compost						tC4 UEF1						tC4 UEF2						tC4 UEF3						tC4 UEF4	TC4 = sum of tC1 $UEF_{1,2,3,4}$
RC 5	C5 usable waste						tC5 UEF1						tC5 UEF2						tC5 UEF3						tC5 UEF4	TC5 = sum of tC1 $UEF_{1,2,3,4}$
RC 6	C6 land Tenure						tC6 UEF1						tC6 UEF2						tC6 UEF3						tC6 UEF4	TC6 = sum of tC1 $UEF_{1,2,3,4}$
RC 7	C7 new Laws						tC7 UEF1						tC7 UEF2						tC7 UEF3						tC7 UEF4	TC7 = sum of tC1 $UEF_{1,2,3,4}$
RC 8	C8 Funds						tC8 UEF1						tC8 UEF2						tC8 UEF3						tC8 UEF4	TC8 = sum of tC1 $UEF_{1,2,3,4}$
RC 9	C9 staff						tC9 UEF1						tC9 UEF2						tC9 UEF3						tC9 UEF4	TC9 = sum of tC1 $UEF_{1,2,3,4}$
RC 10	C10 energy						tC10 UEF1						tC10 UEF2						tC10 UEF3						tC10 UEF4	TC10 = sum of tC1 $UEF_{1,2,3,4}$
by-products																										
waste																										
Products & Services																										
UE Functions	Production functions						total	Habitat functions					total	Regulation functions					total	Amenity functions					total	
Restrictions Urban Ecosyst functions REF	RE Production F							RE Habitat F						RE regulation F						RE Amenity F						

Table 2 describes how various forms of capital (listed in the second column as water, seeds, etc.) connect to Food System Activities (e.g. 'FSA1': production; 'FSA2': Distribution, etc. in the top row) and to the urban ecosystem functions (bottom row). Whilst FSAs generate products and services, they also create by-products and wastes (see the three rows above the UEFs row). Re-using these will be of concern when making cities more circular. Table 2 also highlights the existence of restrictions both in relation to UEFs and to forms of capital use. If EC targets have focused on halting the loss of biodiversity and the degradation of ecosystem services as explained in the EU Biodiversity Strategy 2020, other imperatives are being mentioned.

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In particular,city planners have been called to take immediate action to address the actual ecological overshoot (i.e. the conversion of renewable resources into waste faster than waste can be turned back into resources) - such as finding sustainable alternatives for land use and ways of improving soil regeneration and biodiversity, in order to transition cities towards circular economies and metabolisms [22].

A number of guiding principles, new regulations, ecological and health standards have been identified. Focusing on relating these to the UEFs and forms of capital contributing to these is the objective of Table 3.

Table 3. Restrictions on capital use, protecting EF and the creation of by-products and waste. (compiled by the author).

Capital C		Standards, Targets , Restrictions on capital use (RC)				TCn	Standards, Targets , Restrictions on Food System activities
C1 water	RC1	% of water re-use % of water saved by using agro-ecological processes or others				TC1	**FSA1 Production** Encourage local food production, food security and minimum imports
C2 seeds	RC2	Sustainable provision of seeds Seed bank				TC2	
C3 soil	RC3	% of soil regenerated % of top soil created				TC3	**FSA2 Distribution** Minimize transport and shorten distance for food supply chain
C4 compost	RC4	% of compost used No chemical fertilisers				TC4	
C5 org waste	RC5	% of waste composted, re-used % of waste transformed into energy				TC5	**FSA3 Processing** Add value to waste through innovative processes
C6 land Tenure	RC6	% of waste land re-used/ rehabilitated Efficiency in land-use: crop rotation; permaculture principles…				TC6	
C7 new Laws	RC7	New laws for green infrastructure and corridors New laws about urban agriculture, local production, healthier food				TC7	**FSA4 Education** Create better awareness concerning food production, ecological and human health, food and identity / cultural heritage, agro-ecological practices…
C8 Funds	RC8	Funds generated by adding value to waste Number of Circular projects funded by local authorities				TC8	
C9 staff	RC9	Decrease in unemployment due to new jobs for Circular City % of training on innovative activities for CE leading to a job				TC9	**FSA5 Food waste management** Reduce food waste, re-distribute
C10 energy	RC 10	% of renewable energy used % energy saved thanks to reduced transport (short supply chain)				TC10	
by-products		% of by-product re-used Waste management cost				Protect critical natural capital	Cost saving thanks to circular processes Value added to waste
waste		If waste NOT immediately re-usable: reflection on innovative processes to re-use them or to create product differently					Innovation encouraged through education, funding, new laws; re-allocation of waste into new processes
Products & Services		Meet *Production* needs		Meet *Habitat* needs		Meet *Regulation* needs	Meet *Amenity* needs
Urban Ecosyst. Functions UEFs		Production functions	total	Habitat functions	total	Regulation functions total	Amenity functions total
Restrictions UEFs: RE		RE Production F		RE Habitat F		RE regulation F	RE Amenity F
		Optimise sustainable yield Respect minimum standards and renewability rates		Respect minimum critical ecosystems' size		Max. carrying capacity Protect biodiversity Ensure ecological regeneration	Human health standards Social cohesion Valuable landscpae

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This framework(2) can serve as a basis for checking that needs are being met whilst also protecting urban ecosystems functions and various forms of capital. Using a systemic approach, it is intended to help urban planners to find ways of strengthening the relations among actions, actors, spaces and resources in order to regenerate and improve exchanges between different areas of the cities. By taking a closer look at the overall metabolism of the urban (metropolitan) FS, the objective would be to use an aid to decision-making such as this framework to balance resource, energy and technological flows with a social approach based on the development of local ecosystems of stakeholders, innovative enterprises and integrated value chains.

4.2. A Participatory Approach to 'Urban Circularity Governance'

We can now explore in more depth the necessary participatory dimension in circularity transitions and how such new governance will involve stakeholders of the urban FS. Transitioning a city towards circularity is a complex process which requires various iterations – through 'developmental evaluations' that provide feedback and generate learning. [17] stressed that it is in fact only thanks to a participatory, collaborative, and inclusive, diversified governance process that a transition to a regenerative type of CE could be achieved.

To illustrate their point, they worked on the RePoPP (Re-Design Project of Organic Waste in Porta Palazzo market in Turin, Italy) and showed how the use of CE strategies involving multiple actors against food waste, dynamically intertwined circularity in FS and the design of urban food policies, hence bringing a socio-economic paradigm change in food policies design. For [15], the need for participation stems from the fact that the knowledge(s) and solution(s) produced have to represent the whole variety of perspectives in the framing of complex problems as well as in the decision-making and implementation processes, leading to a new science-policy participatory interface.

4.2.1. Integrating Our Ecosystemic Framework into Urban Planning – How?

[11] concluded that "A regulatory and policy framework is essential for transforming urban systems of provision (…): spatial and land-use planning could provide the arena for innovative CD at a city scale" [11] (p.18). However, she also warns that conflicts between planning regulations and CD goals may also exist. For example, whilst standards for soil decontamination (imposed by planning) may stop brown-field sites from being reused, the adoption of other planning standards in favour of circular solutions might encourage bioremediation - allowing the immediate reuse of the site. When the regulatory framework reinforces the prioritisation of circular goals, circular transformations are therefore more likely. Whilst [51] denounced the fact that food production and security was a stranger to the urban planning field, things have changed in the last twenty years and European and national measures are being encouraged to both produce food differently and to make cities more sustainable. The context seems ripe to grasp both practical examples from which to scale up circular transformations and to change perceptions on urban governance and 'success'.

If urban planning could be subjected to the reforms that are being currently being encouraged, it could focus on the creation of circularity as its main strategy. 'Strategic urban planning' would then need to be 'tailored' to circularity since the latter constitutes a 'moving target'. As [51] explain, transitioning towards "urban resilience refers to the ability of an urban system and all its constituent socio-ecological and socio-technical networks to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change and quickly transform systems that limit current or

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2 A fuller presentation of this framework, intended to be an aid to decision-making in an urban setting, is presented in: Simon, S. (2024) "A participatory urban governance framework for transitioning cities towards sustainability: linking the protection of urban ecosystems' functions and circularity principles" Advances in Urban Regional Development and Planning 1(1): 01-17. https://dx.doi.org/10.33140/AURDP.01.01.06

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future adaptive capacity" [51] (p.39). Various developmental options need to be envisaged to meet people's needs whilst protecting UEFs and the capital upon which they depend.

In order to allow for the planning flexibility that CD requires, [52] advocated using "performance-based planning" – in which the plan (which defines long-term goals and strategies) does not indicate how to pursue the outcomes, but identifies the performance criteria against which actions should be assessed (i.e. the 'Restrictions' in Tables 2 and 3). Performance-based approaches continuously accommodate the new innovations emerging to address the need to re-use waste and by-products, which makes them a suitable way to promote approaches linking ecosystem services and various decision-making processes [52]. Performance based planning could therefore work with our urban ecosystemic framework, aiming at achieving urban transformation that meets certain levels of performance to be considered acceptable – e.g. minimum standards, renewability thresholds, etc. Whilst some of these levels can be identified scientifically, and sometimes specified in new European or national regulatory frameworks, some others (e.g. the percentage of waste water to be re-used in UA) have to be negotiated and aligned with innovative processes that can help to close 'urban circular loops'. The urban circular transformation therefore cannot take place if people do not negotiate and innovate, a crucial component of the circular urban governance discussed here.

4.2.2. Collaborative Circularity - Who?

The circularity of cities calls for reformed governance where stakeholders become better connected and interdependent through more collaborative planning processes [11]. The objective of such 'social innovation' is to build the capacity (expertise, skills and supply chains) among infrastructure and service providers to deliver circular systems of provision in cities – allowing, for instance, construction companies and service providers (water, waste, energy and transport) to design an integrated, closed-loop waste-to-energy system, using learning workshops, direct access to the local planners and regular multi-stakeholder workshops to promote innovation.

The 'Re-Food movement' (https://re-food.org/en/home) is a good example of the potential for success of working together through volunteering and humanitarian support to decrease the food wastage footprint and to help people in need. The Horizon 2020 Project 'Cities: cooperating for a CE' also led to the creation of an online network that helped to manage information about surpluses of meals and food, food donors involved, charity institutions and other stakeholders. These relate to the COST network on Urban allotments gardens in European Cities and to the Milan Urban Food Policy Act (2015) on sustainable food systems).

5. Conclusions

This article critically assessed various dimensions of 'circularity' principles and focused on the illustrative example of circular urban food systems.

First, the article showed that a geographical and institutional contextualisation of 'circularity' can trigger a reflection on what we mean by circularity and why we see it as desirable. Here, we examined circularity in view of identifying how it can contribute to transforming cities into more sustainable and resilient ones – i.e. one of the priorities for the 21st c. The part showed that we both need a practical starting point to grasp the notion of 'sustainable city' and understand better how a circular city can lead to making it sustainable. The practical example we took is urban food systems, since food security has been identified as key to urban resilience. The article therefore shows the links between circularity, sustainability and resilience and suggests a paradigmatic readjustment away from circular economy, technical industrial ecology and new business models in order to prioritise the notions of regenerative, circular development.

In the second part, the illustrative example of food systems helped to discuss the geographical and temporal scale at which urban circularity ought to take place. Taking urban resilience and food security as a main objective in urban transitions, we highlighted the need for both drawing a metropolitan boundary, extending the urban to a new geographical scale that includes the peri-urban as a particular important zone to regenerate, and the broadening of the community of stakeholders

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involved when it comes to sharing knowledge on UA's best practices and promoting new global food democracy systems. This requires a new economic paradigm and decision-making process in favour of cooperation and inclusive governance that can facilitate iterative negotiation.

The third part concluded by presenting an aid to decision-making intended to support such governance, based on regenerative approaches advocated in Part 1, at scales presented in Part 2. Such a platform illustrates a framework from which barometers of circularity can be derived, based both on meeting people's needs and on protecting urban ecosystemic functions. This part therefore approaches the question of who can operationalise circularity and how?.

The objective of this article is to show that making cities more sustainable could be 'kick-started' by making urban food systems circular: this could generate a transformational, domino effect, interconnecting the various urban eco-systemic functions as well as stakeholders linked to urban food production. A critical geographical approach of the circularity paradigm, the geographical and temporal scales at which its operationalisation can take place, and the way in which transformational change can be managed suggest the need for a radical transformation of governance tools and processes in urban planning.

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