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Research Article

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A Participatory Urban Governance Framework for Transitioning Cities Towards Sustainability: Linking the Protection of Urban Ecosystems' Functions and Circularity Principles

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Abstract

The purpose of this research is to provide an urban governance framework that can aid decision-makers to transition cities towards more sustainability and resilience. Our premise is that such transition will take time, iterations and adaptations and will benefit from using a governance framework that is both participatory and that also highlights the ecological, economic and social dimensions of sustainability all at once. In order to do so, we suggest considering the city itself as an ecosystem that delivers environmental functions (production, sink, amenity and regulation) through its activities. Using an accounting representation that links urban activities to these functions, we are then advocating building sustainable urban strategies based on the protection of these functions and on minimising non-re-usable waste or by-products. Encouraging such circularity requires negotiation amongst stakeholders who need to know how production processes could be connected to minimise the overall generation of waste. It also promotes cooperation amongst producers and consumers, and generates collective learning and co-creation. The article shows that adopting an ecosystemic representation can help in understanding circularity as a regenerative approach that goes beyond an accounting balancing exercise. We suggest to integrate design thinking to enhance negotiations based on the information provided by the accounts. The research illustrates how such method could be operationalised by focusing on food system activities, stakeholders, and security as core to urban resilience, using Lisbon Metropolitan Area food strategy as a case study.

Keywords: Urban Ecosystems' Functions, Capacity, Capability, Participatory Adaptive Governance, Circularity Barometer, Urban Transitions.

1. Introduction

Research into ways of helping decision-makers to better design strategies towards sustainability have focused on reforming the main economic indicators (such as GDP) since at least the 1990s. From greening national accounts, efforts progressively turned into creating 'ecosystems accounts'. The dominant approach, developed by the United Nations, led to the creation of the System of Environmental and Economic Account.

The most recent revision of the SEEA - the SEEA Experimental Ecosystem Accounts, or SEEA-EEA (UNSD 2014) - provided a set of standards to compile ecosystems accounts. The objective is to quantify and monitor the contribution of ecosystems to human well-being, to measure the extent and condition of ecosystems services and to improve economic performance whilst protecting ecosystems services (Comte et al., 2022). However, as Chen et al (2023) stressed, there are only few cases of application of SEEA to public policy or planning and SEEA-EEA is still experimental.

La Notte et al. (2019) explained that the precondition for ecosystems to be integrated into economic considerations was their consistency with the System of National Accounts (SNA) - an international standard for the systematic compilation of economic data such as Gross Domestic Product (GDP), used for economic analysis at a national level. Here, we suggest to question this 'SNA consistency imperative', on the basis of the incommensurability of values measured in monetary and non-monetary units, an objection already expressed since research on 'greening national accounts' was initiated decades ago (Simon and Proops 2000). Aligned with this, our point of departure is that, instead of formatting ecosystems into our economic paradigm by identifying them as 'additional production units', we suggest considering the city as a *socio-ecological-economic ecosystem,* which not only provides goods and services but also a habitat, and social and cultural well-being and cohesion.

The focus on the city level is explained by the fact that if the

un-sustainability of our economic systems has been causing concerns, that of our cities is becoming equally urgent. Statistics on cities (UN 2018) reveal worrying trends and have stressed the need for new actions. The New Urban Agenda, announced at Habitat III in response to Sustainable Development Goal (SDG)-11 , called for a 'new paradigm' to "redress the way we plan, finance, develop, govern and manage cities, recognizing sustainable urban and territorial development as essential to the achievement of sustainable development" (UN 2017 p.3).

Approaches to 'sustainable urban development' have developed in the last 20 years. Amongst the various phases that he explored, Roggema (2017) described i) the *"sustainability strategy"* (the degree to which the city is able to deal with the flows determines the level of sustainability of the system, encouraging the design of the city to become focused on the depletion, re-use and recycling of waste); ii) the "emergism approach"(which takes complexity as a key input and the city designer becomes a facilitator in the process of change); and iii) the "resilient cities approaches" (focused on preparing for un-certain futures (Roggema, 2020) or on creating self-sufficient economic, social and environmental systems (De Jong et al., 2015).

It is on resilience and sustainable transitions that the research presented here focuses, adopting a 'regenerative approaches' (Girardet, 2015). Our endeavour is to present urban ecosystems accounts as a way of helping to manage ecological-economic interaction in a more sustainable way, relying on strong sustainability indicators to illustrate the level of protection of the urban ecosystem's functions as well as on circularity principles.

In the context of ecosystems accounting, two novel elements are discussed in this paper: i) how ecosystems accounts can be built and used as decision-making tools at the urban level and ii) how social, participatory element can be taken into account in view of making urban governance participatory through an iterative process. The objective is therefore theoretical (in that new criteria provide a solid foundation for building urban ecosystems accounts) and practical (in that the accounts are aimed at being used as a governance, negotiation, tool to co-create transitions towards a type of 'urban sustainability' that would be both ecologically, sociologically and economically sound).
The article suggests an application focused on urban food security where the urban ecosystems accounts illustrate the way in which food system activities contribute to the delivery of urban ecosystems functions and are core to urban resilience.

2. Materials and Methods

2.1 Ecosystems Accounts for Cities? Approaches Undertaken so Far

Even though they haven't always been called 'urban ecosystems accounts', Material Flows Accounts (MFA) have been developed in the past to describe the functioning of the 'urban metabolism'. They do so, as Castan Broto et al. (2012) explain, by "systematically assessing the flows and stocks of materials within a well-defined system, connecting sources, pathways, and sinks of materials" (p.853). Applied originally at the national level, more studies of cities' MFA have been carried out since the 1990s (Kennedy et al. 2011) but remain limited (Niza et al. 2009) due to constraints such as the need to extrapolate data that is available at the country level.

The idea of the city having a metabolism was originally influenced by systems ecology studies (Slocombe 1993). As Ulgiati and Zucaro explain (2019), cities are complex entities whose own metabolism is very dependent on areas that are outside their boundaries to provide them with raw materials and energy and to assimilate their waste to sustain their functions. Complex systems theory builds on this, stressing that *urban ecosystems* consist of multiple interlinked subsystems in continual interaction with each other and the outside world (Alberti 1999). The exchange process which results from these interactions characterises the urban environment.

Odum (1989) viewed these interactions in a very sceptical way, considering the city as a parasite which deprives its surrounding area of its resources and pollutes it in exchange. This unflattering vision of the city invited reflections on the problematic character of the organization of inputs and outputs in urban areas, consuming and producing waste according to a model of "linear metabolism". It also encouraged people to explore whether cities could be managed differently by mimicking the efficient, cyclical, way in which natural systems use materials and energy and by being more conscious of sustainability aspects related to the *quality and typology of metabolism* (Cui et al. 2018). For Girardet (1992), this could be made possible if cities shift to a circular metabolism model in which outputs are recycled into the system and for which urban management becomes *regenerative*. More recently, Cardenas-Mamani and Perrotti (2022) started exploring the causal relationships between ecosystem services and economy-wide MFA.

In view of linking urban metabolism to policy strategies in order to measure and change urban sustainability performances, we advocate developing practice of urban metabolism in a more interdisciplinary way than MFAs. The next paragraph presents the conceptual foundations of the framework we are developing to do so.

2.2 Urban Ecosystems Accounts (UEA) to Protect Urban Ecosystems Functions (UEF)

New approaches of urbanism aimed at making cities more sustainable attempt to provide governance guidance, often by trying to design barometers to identify whether urban transformations are going in the 'sustainability' direction. It is in the context of this objective that exercises on 'accounts' can be best understood.

In line with complex systems theories, we have explored the idea that, rather than adjusting urban metabolism to make cities ecosystems *more stable and predictable,* developing an aid to urban governance that *contributes to achieving greater resilience* to the inevitable internal and external shocks that will impact cities could be useful. Making cities *more resilient* would mean, as Meerow et al. (2016) explain, that the urban system would be able to maintain or return to desired functions in the face of a disturbance, to adapt to change and to transform systems that limit current or future adaptive capacity.

To develop such a tool, we suggest constructing ecosystems accounts at the level of the city that describe how the various activities carried out contribute to the city acting as an ecosystem. The city activities, themselves relying on the use of various types of capital, enable the UEF to be performed as shown in Table 1. .

ECOSYSTEMS FUNCTIONS	City activities – e.g. main ones in Lisbon contributing to the provision of ecosystems services through ecosystems functions	Public administration and defence	Manufacturing and processing	Health	ICTs	Creative/ educational activities	Financial and insurance activities	Construction infrastructures (incl GI)	Real estate	tourism	commerce	FOOD SYSTEM
Production	Urban Agriculture production			*		*					*	*
	Manufactured and processed food products		*								*	*
	By-products / waste that can be re-used	*	*		*	*		*	*		*	*
	Waste/pollution that cannot be re-used without new technol.	*	*		*			*	*		*	*
Habitat	Provisiono of buildings (accommodation and other public/private buildings)							*	*			
	Reconversion of spaces for different uses	*		*	*	*		*	*			*
	Provision of infrastructures for transport and connections	*			*				*			
	Provision of hospitals, train stations, museums, public spaces, schools…	*							*			*
Regulation	Ecological regulations e.g. CO_2 absorpt.											*
	Heat waves/ temperature regulation/ green infrastructure/ flood regulation							*				*
	Budgeting/ allocation of resources to create jobs and ensure economic stability	*			*		*					*
	Management (e.g. sewage) and recovery of waste; composts, substrats, wastewater…	*										*
	Improvement of urban ecological health (better spatial and ecological balance between neighbourhoods)	*		*				*				*
	Planning activities and land management to promote permaculture city	*			*			*				*
	Health services (hospitals, doctors, expertise…)	*		*	*							
	Tackling crime and promoting safety and inclusivity in city	*		*	*	*		*	*			*
Amenity/ Information	Green space and infrastructure	*		*		*		*		*		*
	Urban environment promoting mental and physical health			*		*		*			*	*
	Cultural identity through food							*		*	*	*
	Cultural mix/ co-creation of urban places and communities			*	*			*	*	*		*
	Learning new ways to co-create urban spaces/ innovate	*		*	*			*	*	*	*	*
	Education services (formal and informal; long-life learning…	*		*	*					*		*
	Leisure, recreation, museums, …			*	*			*		*		*

Table 1: Contribution of Cities' Activities to The Functioning of Urban Ecosystems

In order to understand this structure, which parallels the functions of an 'urban ecosystem' to those of an 'ecological ecosystem', we first need to remind ourselves of a few key ecological notions.

2.3 Environmental Functions, Services and Forms of Capital

De Groot (1987) considered that the notion of environmental functions "could become a useful unifying concept to provide a long-term goal for both economists and conservationists" (p.105) since environmental functions are at least as important to human welfare as man-made goods and services. The term highlights the fact that meeting human needs cannot indefinitely be done without protecting our ecological life support. In the same way that the notion of Ecological Services (ES) is being used, following the Common International Classification of Ecosystem Services (CICES) (Fairbrass et al. 2010), Ecosystems Functions (EF) are now understood as including Production, Habitat, Regulation and Amenity functions (Hein et al. 2016).

Production functions describe the ability of ecosystems to provide human communities with raw materials that become food, fuels, metals, timber. *Habitat functions* are the functions that provide us with a liveable place for our communities to

settle with enough space. Regulation functions provide the basic context and conditions within which life is possible (with carbon and water cycles). *Regulation functions* also include the ability of ecosystems to absorb waste (through dilution or the absorption of CO_2). As Ekins et al. (2003) explain, these *sink functions* might be jeopardised if the amount of waste 'injected' exceeds the ecosystem's ability to absorb it – and hence deteriorates it. If, on the contrary, human communities can use their waste (e.g. through the fertilisation of soil by livestock or compost), then the stock of ecological capital is being regenerated through an 'investment in ecological capital'. Finally, the *amenity functions* contribute to human welfare and health (through humans' contact with and enjoyment of nature).

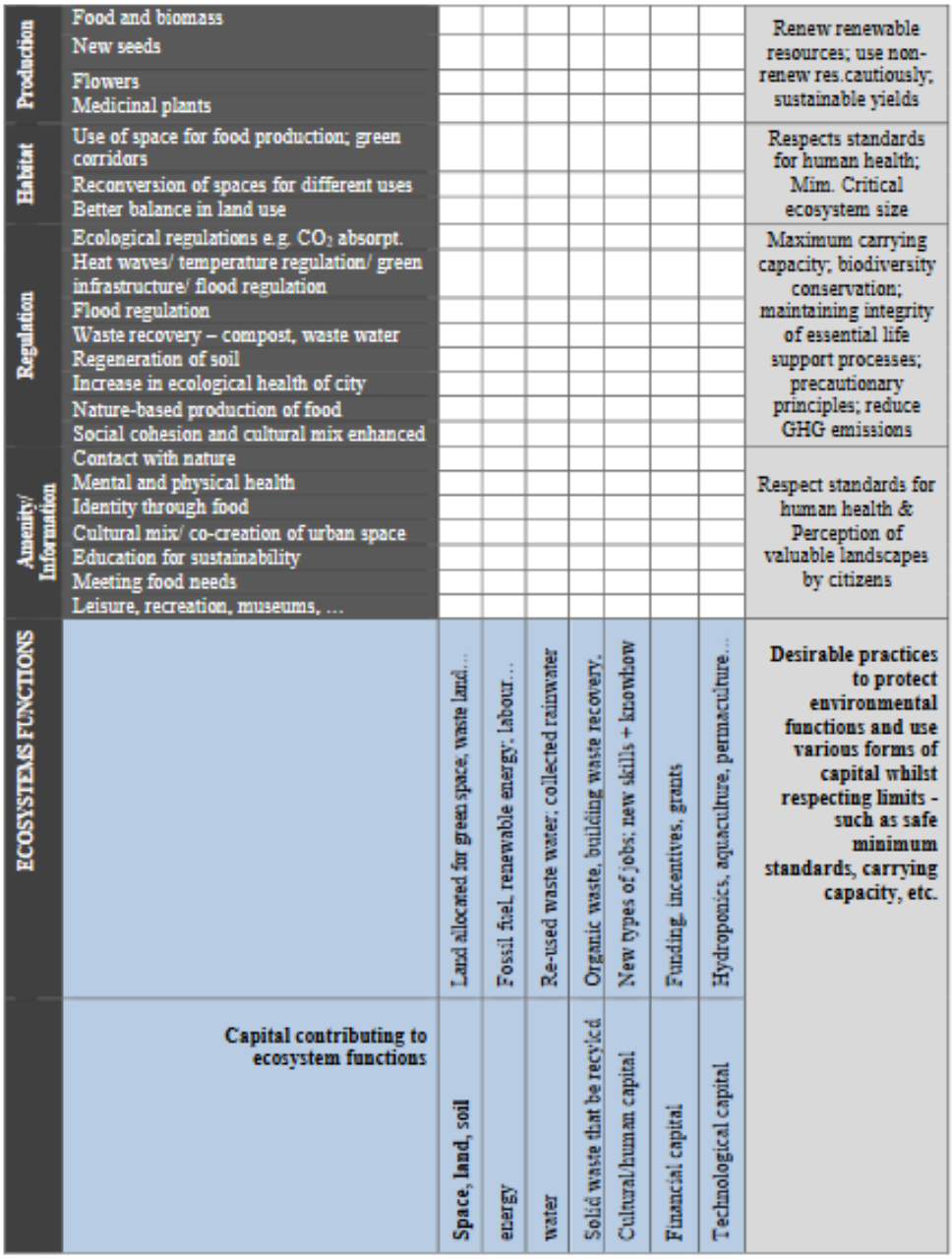
So, what are *Urban* Ecosystems Functions? Going beyond the approach of cities as 'urban metabolisms', new scientific communities of urban ecologists (Forman 2014) and urban landscape ecologists (Pont et al. 2017) have developed an interest in exploring the role that ecological systems can have in improving the adaptive capacity of urban areas in addressing the imperative to *maintain essential ES,* and in understanding better the importance that urban forms, or patterns, within the built environment, can have in *supporting environmental functions* (Palazzo 2022). The role of un-built spaces in the formation of the urban 'organism', is also viewed as requiring more investigation (Whitehand 2019). Other research focused on the use of permaculture – a set of decision-making tools based on natural systems for creating 'regenerative solutions' – to apply to cities as complex adaptive systems "in view of allowing new properties to emerge such as self-regulation, self-organisation and resilience" (Hemenway, 2015, xi). As Marcus et al. (2019) conclude, conceiving cities as urban ecosystems would help us in guiding urban systems towards trajectories to greater environmental sustainability.

Our proposed path is to build an UEA framework as an aid to decision-making and urban governance that is participatory, iterative, and based on the idea that protecting UEF will help in progressively making the city more sustainable, through a socio-ecological-economic transition.

Urban ecosystems perform 'functions' which deliver goods and services that are beneficial to their urban dwellers, whilst maintaining their own survival. The two are inextricably linked. As Table 1 showed earlier, urban ecosystems perform '*production functions'* - they deliver goods (such as food produced in the city, manufactured goods, etc.). They provide a '*habitat*' to people who gather in cities, demonstrating their interest in living in communities (including both private homes as well as buildings that are publicly used (e.g. stations, hospitals…), and spaces specifically used to connect 'bits of the city' together (e.g. roads, blue and green infrastructure). The balance between these types of habitats (natural versus man-built) is beginning to be recognised as crucial for human well being and for the health of the urban ecosystem itself. A number of activities (dealing with crime or with people's health) help with the *regulation functions* of a city from social perspectives. Others focus more on the ecological dimensions necessary for the maintenance of the *life support functions* (e.g. CO_2 absorption thanks to green infrastructures). Finally, the urban ecosystems *amenity/ information functions* provide the much sought after educational and cultural services that cities offer.

As Table 1 shows, activities (in the right columns) contribute to the performance of UEF in various ways. Whilst some affect certain functions in particular (e.g. manufacturing will contribute to the provision of certain goods without greatly affecting the delivery of other functions), some other activities (e.g. creative and educational ones) are much more transversal and affect whether *various* ecosystems functions can deliver goods or services to urban dwellers. Protecting UEF can be done by promoting certain activities through strategies designed by urban planners through governance processes. The balance in goods and service provision by the functions can also be affected by the types of *capital* needed for the activities and functions to be performed. Various forms of *natural capital* are found in the ecosystems assets (plants, water, soil) which themselves can combine and generate flows of benefits to people and ecosystems. Some forms of natural capital renew and replenish themselves. However, some others do not and are not substitutable either. Learning to manage them in precautionary manners in view of respecting renewability thresholds is part of the ethos of 'sustainable management'. In practice, for Ekins et al. (2003, p.6), managing natural resources and protecting EF means paying particular attention to *Critical Natural Capital* (CNC), described as being "responsible for important environmental functions and un-substitutable by manufactured capital". Identifying CNC is important when trying to operationalise strong sustainability: this can be achieved by maintaining important environmental functions and the capacity of the capital stock to provide those functions (Fairbrass et al.,2020).

Table 2 illustrates how various forms of capital (not only natural) are needed to contribute to UEF. It focuses on the example of a certain type of urban activity: that of Urban Agriculture (UA) – which affects all functions. The bottom row lists forms of capital needed in UA (land, energy, water, composted and other recycled waste, funding and cultural capital). Note that each type of UA activity can be working with a table such as Table 2 to identify what quantity of capital is needed, in order to contribute to certain functions whilst respecting constraints.



Production	Food and biomass								Renew renewable resources; use non-renew res.cautiously; sustainable yields
	New seeds								
	Flowers								
	Medicinal plants								
Habitat	Use of space for food production; green corridors								Respects standards for human health; Min. Critical ecosystem size
	Reconversion of spaces for different uses								
	Better balance in land use								
Regulation	Ecological regulations e.g. CO_2 absorpt.								Maximum carrying capacity; biodiversity conservation; maintaining integrity of essential life support processes; precautionary principles; reduce GHG emissions
	Heat waves/ temperature regulation/ green infrastructure/ flood regulation								
	Flood regulation								
	Waste recovery – compost, waste water								
	Regeneration of soil								
	Increase in ecological health of city								
	Nature-based production of food								
	Social cohesion and cultural mix enhanced								
Amenity/ Information	Contact with nature								Respect standards for human health & Perception of valuable landscapes by citizens
	Mental and physical health								
	Identity through food								
	Cultural mix/ co-creation of urban space								
	Education for sustainability								
	Meeting food needs								
	Leisure, recreation, museums, …								
ECOSYSTEMS FUNCTIONS		Land allocated for green space, waste land…	Fossil fuel, renewable energy; labour…	Re-used waste water, collected rainwater	Organic waste, building waste recovery,	New types of jobs; new skills + knowhow	Funding, incentives, grants	Hydroponics, aquaculture, permaculture…	**Desirable practices to protect environmental functions and use various forms of capital whilst respecting limits - such as safe minimum standards, carrying capacity, etc.**
	Capital contributing to ecosystem functions	**Space, land, soil**	energy	water	Solid waste that be recycled	Cultural/human capital	Financial capital	Technological capital	

Table 2: Forms of Capital Used By UA to Contribute to Urban Ecosystems Functions

Urban governance systems that include UA in urban sustainable strategies would manage these forms of capital and activities so that the *capacity* and *potential of ES* is being considered carefully. Similarly, for each EF, the way in which capital is being used should respect some limits (indicated in the right column of the table). Thus, in the context of production functions, *renewability thresholds* should be respected. For the habitat function, attention should be given to *minimum critical ecosystem sizes* needed to meet the needs of a certain community. *Critical pollution loads* should not be exceeded so that certain regulation ('sink') functions can carry on being performed. And *standards related to human health* (e.g. need to access greenery and shade) should be respected in the context of amenity functions.

2.4 Linking These Notions with Urban Resilience and Sustainability

In terms of CNC, as Ekins et al. (2003) explained, it is possible to identify the physical 'distances' to 'environmental sustainability', expressed in physical terms, that indicate that CNC is being depleted. It corresponds to the difference between the current situation, the state of the natural capital stock or the pressure being put upon it and the sustainability standard – in other words, the *Sustainability Gap* (SGAP) for a specific environmental function (p.18).

If sustainability can be conceptualised using the formulation of CNC (Fairbrass et al 2020), it can also be envisaged with respect to the relationship between *ecosystem condition, capacity and flow of services* (La Notte et al. 2019). In effect, as Heymans et al. (2019, p.8) put it, "a sustainable (urban) landscape is one in which the potential and the outputs of ES is maintained and the *capacity* of those systems to deliver the same ES for future generation is not undermined". An *ES deficit* appears when the demand for ES becomes higher than the *ES potential* (Vallecilo

et al., 2019). The *ES Potential* has been described by Vallecilo et al (2019) as the service that the ecosystem can potentially provide depending on their type, extent and condition. When this ability to generate the service is considered irrespective of the demand for it, it is called ES potential. An ecosystem service can therefore be overused if the actual flow is higher than the potential flow; which can cause degradation, reflecting the fact that the ecosystems capacity to provide the service is decreased. The *difference between the ES potential flow and the actual flow* therefore provides an indication of how sustainably or unsustainably the service is being used. In addition, the ecosystem capacity has been defined as its ability to sustainably generate a set of ES into the future' (UN et al. 2014b).

As Hein et al. (2016, p.4) explain, "ecosystem capacity must reflect the stock of ecosystem capital and its ability to supply individual ES over time. (…) *When all ES are used at a level below or equal to capacity,* it is implied that the supply of services in theory is sustainable in perpetuity". ES supplied at a level above the ecosystem's capacity would therefore lead to a degradation of that ecosystem, itself illustrated in 'condition indicators'.

From an urban governance perspective, it is possible to focus on urban ES and UEF, in view of identifying ES potentials and capacity, and design strategies that will enhance the protection of the urban EF and of CNC that facilitates the provision of ES. However, the various stakeholders belonging to the urban ecosystem may react differently to the 'sustainability constraints' put on ES - depending on their perspectives and needs. In a context within which participatory approaches to urbanism are being explored, it is important to reflect on ways in which stakeholders could contribute to designing transitions towards sustainability.

2.5 Cities as *Socio*-Ecological-Economic Systems: Integrating the Human Dimension

The need to integrate the social dimension into approaches focused on ecosystems is taken more and more seriously with authors such as Comte et al. asserting that "overall, it seems that more in-depth collaboration between scientists and stakeholders outside academia is needed to improve policy uptake of ecosystem accounts" (2022, p.13). Urban ecosystems are indeed made of multiple interconnected social and ecological processes in which flows are shaped by the historical context in which they emerge. "Rather than distancing humans from nature", urbanization can therefore be seen as "a process by which new and more complex relationships of society and nature are created" (Keil 2003 p. 729).

Planning for urban sustainability needs to work on the basis that cities are dynamic, self-organising socio-ecological systems that experience constant evolution and changes. Because of its unpredictable character, "the sustainability of the urban system is dependent on its resilience capacity *–itself arising from its adaptive capacity, in a non-equilibrium context"* (Heymans et al. 2019 p.10). Such adaptive capacity will have to involve the *adaptability of human capital* as a key factor.

The integration of the human dimension into our UEA framework is presented below. The proposal first emphasises how the UEA approach could facilitate economic cooperation through *circular cities principles* and, secondly, suggests using Design Thinking to help stakeholders to negotiate which potential alternatives could facilitate a transition towards urban sustainability by better protecting urban ecosystems functions.

2.6 Making the Economy More Cooperative: Highlighting Potential Partnerships and Circularity

The principle of a Circular Economy (CE) (EMF, 2020) is that the economy 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. For Liaros (2020) CE makes us think of cities as systems that provide residents with their basic needs for water, food, energy and shelter in an efficient way.

UEA can illustrate how activities that facilitate the delivery of ES both use various forms of capital and, often, create *by-products*. These by-products can either be re-used as inputs in existing production processes or activities – i.e. 'innovations' that enable a closing of CE loops – or else remain as waste or pollutants. Such situation is however undesirable. The objective of the UEA is therefore to identify both how by-products can be re-used as inputs or re-assigned value by being transformed, and also how this can be done in view of protecting the ecosystem's capacity and overall sustainability. Rarely will it be possible for one type of by-product generated by an activity X to be re-used by the same activity X. On the other hand, another activity Y might find a good use for this by-product. If no other activity can be considered for dealing with the by-product, thoughts might be put into either trying to generate a new type of innovative activity that will use it, or else reflection might be needed to consider whether it is possible to find another way of producing the good initially needed without having to generate any un-wanted by-product.

Encouraging CE at the city level requires communities to take more responsibility for their local environment. Table 3 illustrates how the activities (in the central column) use forms of capital to contribute to UEF (in the left part of the table).

Considering the interrelation between products and by-products (waste) creators and users does require a good knowledge of the 'landscape of producers and users' at the level of the city. The creation of such cooperative network presupposes that circular economies principles have been encouraged by urban planners and that the stakeholders involved do have visibility on the production of by-products. This is when creating a participatory urban governance tool becomes particularly key. However, this 'participatory decision-making' element is currently lacking in most cities . While Greer et al. (2022) addressed this governance shortcoming by designing a decision-making tree, we are suggesting to tackle the lack of circular-oriented governance by using an UEA *combined with a Design Thinking approach*.

ECOSYSTEM FUNCTIONS					Example of types of CAPITAL NEEDED TO PERFORM ACTIVITIES							
Production	Habitat	Regulation	Amenity									
e.g. Food	e.g. Green spaces	e.g. CO_2 absorption	e.g. Recreation education	Urban activities	water	Energy	New laws	funds	staff	others	By products pre-created	
				Activity 1								
				Activity 2								
				Activity 3								
				Activity 4								
				Activity 5								
				... activity n								
				ES potential							Total By-products	
				ES demand								
				E capacity								
Max. sust. Yield; min. safe stand. Renew res.	Min critical Ecosystem sizes	Max. carrying capacity	Health standards/ valuable landscapes	Urban activities	water	Energy	New laws	funds	staff	others	Re-use of by-products	
Conclusion: negotiated % future Q to be produced to address the GAP/ capacity					Conclusion of negotiations for next period: How should by-products be re-used and by which activity? How should capital be better used?							
				Activity 1								
				Activity 2								
				Activity 3								
				Activity 4								
				Activity 5								
				New activity								
					% waste water reuse	% renew energy used	New land use policy for reconversion	Funds generated by add. value	% unem-ploy-ment		% by pro-ducts re-used	Indicators of circularity

Table 3: Indicators of Circularity as Guidance for A Cautious Use of Capital to Contribute to UEF

2.7 Making UEA Participatory: Adaptive Governance Using Design Thinking

Dynamic adaptive governance requires the involvement of stakeholders in creative policy and encourages learning through innovation and experimentation. Governance tools helping to generate such a dynamic decision-making situation should therefore be iterative and cyclical (Roggema 2017). The development of such tools is currently being encouraged

to protect interests and values of different stakeholders. Beyond using the circularity barometers circularity mentioned earlier, how can stakeholders discuss their varying perspectives and needs?

In order to contribute to a practical transition towards creating a sustainable city, various iterative steps will have to be taken and various 'priority problems' will need to be tackled separately (whilst examining the urban EF they affect). One particularly useful approach to proceeding in this way is Design Thinking (DT). Here, we propose to use it to negotiate possibilities both for CE and for reaching sustainability and urban resilience, using information provided by the UEA. Figure 1 illustrates, in what has become its classic 'diamond shape', the various steps taken in the DT approach developed by the UK Design Council (Brown, 2009).

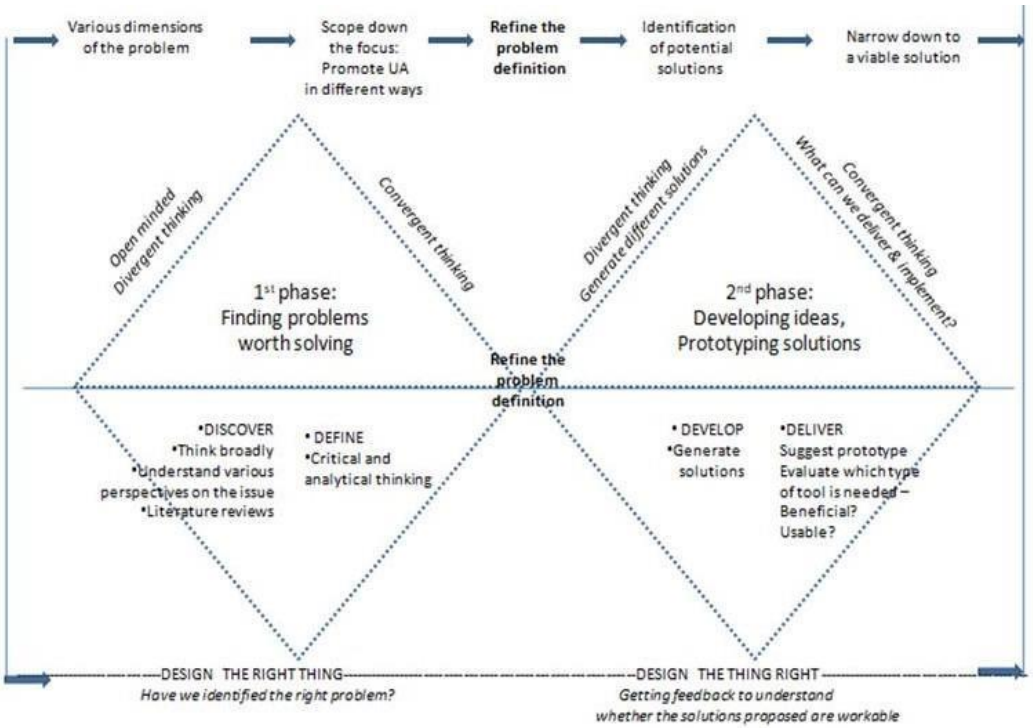


Figure 1: The Diamond-Shaped Design Thinking Approach (Uk Design Council. https://www.designcouncil.org.uk/)

Brown (2009) describes DT as a problem-solving approach whose objective is to identify which solution(s) can help to get out of a complex situation that seems to be going no-where.

The idea is to carry out a participatory process that allows stakeholders to think together of both many aspects of a problem and many solutions, and to identify which specific aspects of the problem people should focus on in priority and why, leading to the identification of the most preferred solution.

In a first stage, people collectively discuss about the problem at stake by describing many aspects of it and then, through one selected perspective, by trying to *narrow the problem definition* (what, really, is the problem?). The second phase focuses on how to address the problem. After brainstorming on as many as possible potential solutions, a second converging phase narrows down the identification of the solution with the highest impact for the lowest effort. In our case, we start with the realisation that we still don't fully know what a 'sustainable, resilient city' is and what to do to activate a transformation to improve the city. A DT activity can initiate a reflexion on challenges associated to transforming the city in this direction whilst protecting ecosystems functions and respecting circularity constraints.

The next part will illustrate how focusing on a case study, for instance the urban food system, can be insightful as a starting point in a sustainable transition.

3. Results and Discussion

3.1 The Lisbon Metropolitan Area Food System Case Study

Different approaches have been taken to make cities more sustainable. Greening cities has been a popular path, even rewarded, since 2010, by titles such as 'Green Capitals of Europe given by the European Commission. In the case of Lisbon, for instance, the city tackled twelve environmental indicators and, in particular, reduced its CO2 emissions by 42% (2002-2014) and its energy consumption by 28% (2012-2017). It also increased people's usage of public transport by 20% in 2019 and considerably increased its surface of green areas. In the publication describing these achievements (EU, 2020), Virginijus Sinkeviius, the EU Commissioner for the Environment, Oceans and Fisheries, described the Green European Capital 2020 as a "role model for combining sustainability and economic growth in a green transition that improves the quality of life of citizens and creates sustainable local jobs".

It is however not entirely clear why 'greener cities' would be 'sustainable', especially when considering sustainability from ecological and socio-economic perspectives. The Covid crisis highlighted the lack of resilience of cities that were otherwise 'green'.

Research on Lisbon's MFA was carried out to "support the definition of performance indicators and targets to be integrated into the energy and environmental strategy for Lisbon", since "non-renewable resources represented then almost 80% of the total material consumption, and renewables' consumption (biomass) constitutes only 18% of the total consumption" (Niza et al., 2009, p.384). However, we feel that, especially in view of the city's dynamism in promoting UA activities, it would be of particular interest to illustrate the place of food strategies in a transition to sustainability, using the UEA governance tool presented earlier.

3.2 Food Security as Core To Urban Resilience and Sustainability

In this part, we illustrate how urban food security -, described by some as key to urban resilience, circularity and sustainability (Yan and Rogema 2019; Remmers 2011; EMA, 2019) - could be investigated using the UEA framework we designed, as a way of 'kick-starting' a transition towards sustainability and circularity. Urban Agriculture (UA) activities, in addition to facilitating production functions to deliver goods, also contribute to regulation and amenity/information functions as illustrated in Table 4, hence contributing to *all* ecosystemic functions.

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 training
	Recreation and culture	Walks and fruit-picking 'tours'
	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 and re-use	Building material for parks, greenhouse…
	Building/ land recovery	Reconverted land for green corridors
	Organic waste transformed into compost	Compost used in large quantity
Regulation functions Life support functions	Restoring/ protecting water cycles	Reed cultivation to absorb floods
	Regulation of temperature in city	Create shade and cooling
	Biodiversity protection	Varied species planted
	Landscape ecology	Green corridors
	Governance of the urban ecosystem's circularity	New jobs in UA, landscape ecology, .. Facilitators for negotiations and governance

Table 4: ES delivered by UA through Habitat, Information, Sink and Life Support functions

As the Covid-pandemic illustrated, we have become very dependent on globalised systems (such as the global imports and exports of food) whose fragility can have important impacts both globally and locally. Since 80% of the global demand for food comes from cities, one can appreciate how food security, which was jeopardised then, could be further weakened by another similar crisis – against which building our resilience would be strategic. The notion of resilience was originally used to refer to systems and their ability to cope with external shocks and disturbance and to absorb outside disturbance while maintaining former structures and functions (Holling, 2001). Our objective is to analyse how our UEA and negotiation methodology could be used to progressively consolidate urban resilience. Bullock et al (2017) define resilience in the food security context as "maintaining production of sufficient and nutritious food in the face of chronic and acute environmental perturbations" (p.880) and being represented by the amount of time that food production is below a 'sufficient and nutritious' threshold.

Whilst resilience - in the context of food security - has been conceptualised at different levels (e.g. at a global level when exploring it in terms of international development, or much more locally, when analysing ways to maintain agricultural production under climate change (Altieri et al. 2015)), we have chosen to focus on the urban food system level and its resilience. Our definition is taken from Tendall et al. (2015) who describe it as the capacity over time of a food system and its units at multiple levels, to provide sufficient, appropriate and accessible food to all, in the face of various and even unforeseen disturbances. This is because the production of food for the city through UA is mostly done at the periphery of cities, at the level of the 'Metropolitan Area' (Hemenway 2015). It is therefore at this scale that we suggest to examine the benefits of urban food production in terms of ES and EF.

As mentioned earlier (Table 4), UA and the other activities of the food system seem to generate particularly numerous benefits across the whole range of urban EF. Conversely, food systems stakeholders, by negotiating urban management and activities alternatives and strategies aimed at improving the food system

resilience, can positively affect many other non-specifically food related activities in the city. Working on the resilience of a metropolitan area's food system might therefore contribute to boosting an urban ecological transition. Focusing on the food system to think about urban sustainability is also particularly relevant because it links important issues and various dimensions of sustainability and is, as Yan & Roggema stress (2019), a particularly key facilitator of nexus thinking, needing land, water and energy to be productive. The 3 guiding principles of such nexus thinking encompass 1) Ensuring accessibility of food, water and energy to all; 2) Creating more with fewer costs; and 3) Investing in ecosystems systems to secure FEW provisions.

This approach delves into urban space and design solutions from the perspectives of end-users. In addition, as has been shown in the case of Lisbon, using food in the context of 'urban ecological transition' in view of boosting *participatory urban governance* could be promising since people have shown to be involved in various types of UA initiatives, private or collective, programmed by the local authorities or else sparked spontaneously – in all cases, people's motivation is important, practical and meaningful enough for people to show willingness to participate in the long-run (Simon, 2022). Other factors (presented in Figure 2) make using the food system of Lisbon a compelling case study.

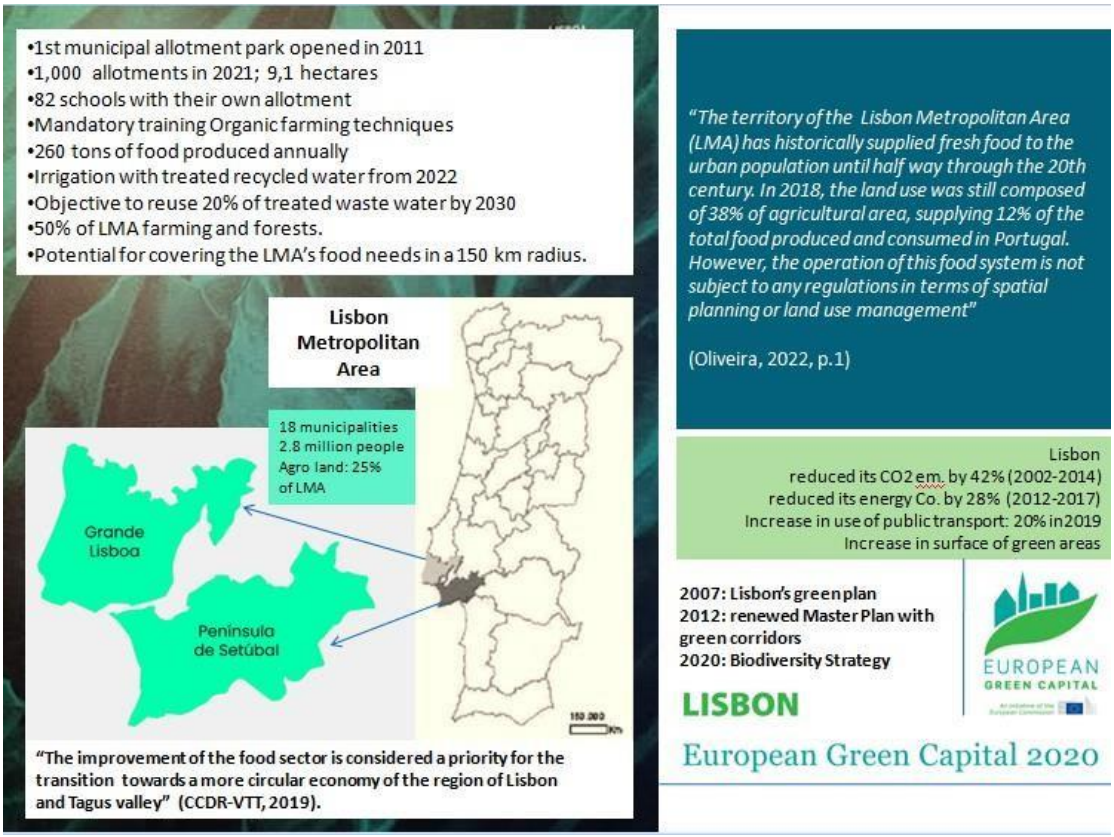


Figure 2: Some Important Characteristics of the LMA and its Food System

Agendas in favour of sustainable cities with food resilience at their core include, for instance, the Milan Urban Food Policy Act 2015, the EC Farm to Fork strategy (2020) and the 2030 EC's Food initiative. These have influenced national initiatives. In Portugal, for instance, the National Strategy and Action Plan for Combating Food Waste, and the introduction of new criteria for the procurement of food products to the public (Law 34/2019) are having an impact on how urban transitions are progressively envisaged. In addition, HABITAT III Portugal highlights the need for improvement in transports in Lisbon and encourages CE.

The "Lisbon 2030 Strategy [8]" has recognized the importance of strengthening the food system in the Lisbon Metropolitan Area (LMA) by increasing food resilience, also acknowledging the fact that "urban Planning is strategic to account for the sustainability of the several systems that operate within the territory, including the food system, because it directly impacts on the productive spaces necessary to guarantee the food provision for the city" (Dias and Marat-Mendes 2020, p157).

3.3 Urban Ecosystems Accounts and the LMA Food System

The urban ecosystems accounts can help to visualise the links between the LMA's food system activities, its ecosystems functions and the urban governance DT negotiation process. Such visualisation could help in reforming the urban foodscape through the creation, for instance, of new innovative activities that use by-products and that would involve the creation of new jobs that could financially support urban food circuits. For each of the ecosystems functions of the food system, it is possible to identify these links, as illustrated in Figure 3 below. One can recognise the schematic representation of the DT negotiation 'diamond shaped' diagram that separate the upper parts of ecosystems accounts to their 'bottom parts' – symbolically

representing the negotiating phase using information from the accounts and feeding the accounts for the 'next period' (3 months would be a suggested time period for frequent participatory urban governance).

Table 5 focuses here on the activities encompassed in the food system of the LMA. Within it, we find production, processing, and distributing activities, for instance. Entering data here would illustrate that the food system of a city actually contributes to much more than to the production functions, since they help with people's physical and mental health, help to directly address issues of climate change in urban environments, promotes socio-cultural cohesion, and contribute to creating innovative jobs, for instance.

Below the total, demand and gap rows of the table, the bottom part of the ecosystems account deal with the next temporal period to be taken into consideration. Note that, in the context of the SNA, this corresponds to a civil year. However, and especially in the case of iterative urban governance ecosystems accounts, the period of consideration would have to be much shorter to ensure frequency, adjustment of complex systems, and progressive design of resilient interrelations. In addition, when considering activities such as those included in the food system, ecological considerations on which the production of food depends (e.g. seasonal variations) would be key to collect data and to negotiate next stages.

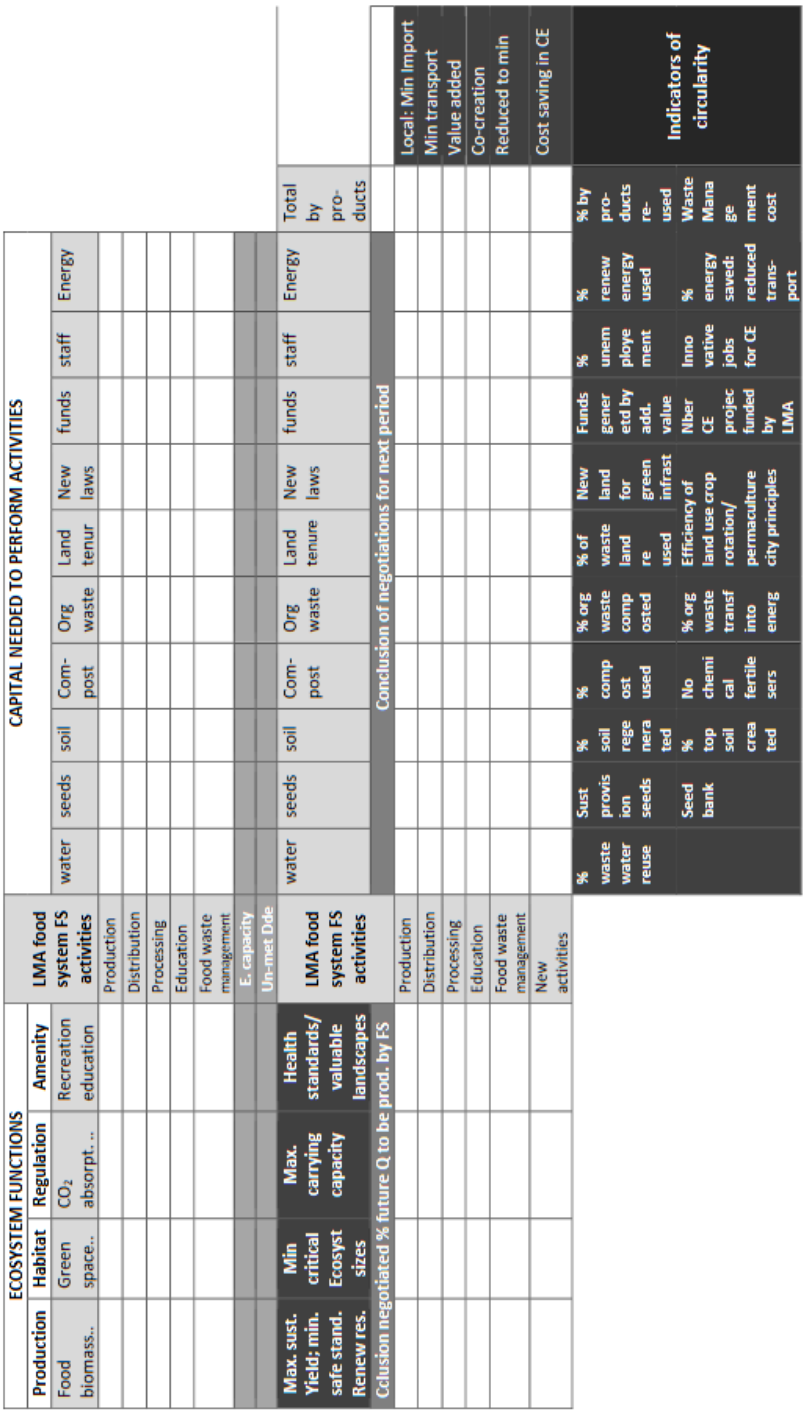


Table 5: Indicators of Circularity as Guidance for A Cautious Use Of Capital Forms in Order to Contribute to EFS At the LMA Food System Level

In the bottom part of the table, ecological and circular *constraints* are indicated: i) those related to ecological functions (such as minimum standards, maximum yields, renewability thresholds, etc.) are indicated below each ecosystem function; ii) those related to forms of capital (e.g. percentage of waste water or wasteland re-used/ valorised) are positioned below each form of capital; and iii) those related to production processes (e.g. constraints such as value-added to products through innovative transformation, or minimisation of miles covered to distribute the food). These various constraints and thresholds or standards are either defined 'scientifically' (by ecologists for renewal rates, for instance, or by doctors for human health standards), or discussed as urban strategies resulting from a political will to, for instance, shorten food chain distributions, or eliminate food waste.

By combining UEA and DT negotiation, our objectives are therefore a) to ensure that the ecological functions of UA are delivered and act as a basic for a sustainable food system; b) to facilitate people's understanding of how ES and Environmental Functions contribute to urban Sustainability; c) to identify the types of capital and stakeholders who ensure that the environmental functions work; d) to identify what already exists and what is missing to contribute to these functions to be delivered and e) to do so in a participatory way. All this needs to be done whilst respecting priorities set by national or regional priorities (such as the Innovation Agenda for Agriculture 2020-2030 (RCM N086/2020 13 Oct) in the case of Lisbon (Oliveira, 2022, p.14) which stipulates that changes should lead to

- An increase by 20% of the level of adherence to Mediterranean diet
- An increase of the value of agricultural food production by 15% (thanks to the creation of proximity food circuits)
- A way to ensure 50% more agriculture area under recognised sustainable production scheme
- An increase of 60% in research and development investment on transition to sustainable food
- A correction of the national food ecological footprint (currently three times the biocapacity of ecological systems to regenerate due to an excessive consumption of meat and fish)
- A better articulation of the 18 municipal plans in the LMA on food production and security with a better focus on waste and food waste management and food processing and manufacturing.

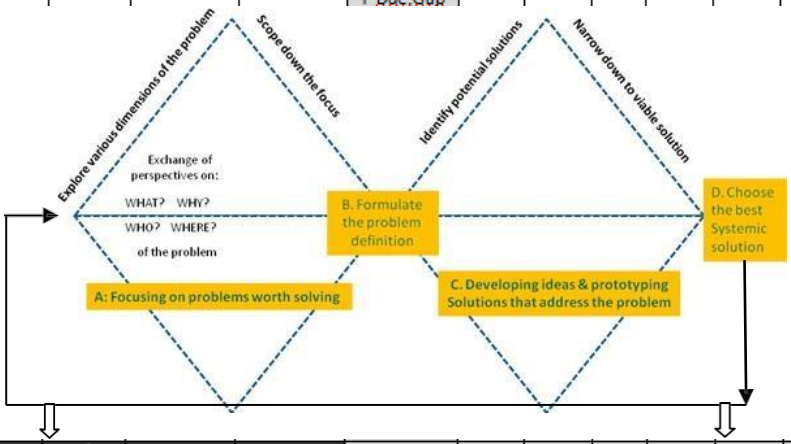
As Greer et al. (2022) stressed, "one important reason why the transition to a CE is difficult can be found in the decision-making processes: suitable frameworks that support decision-making in a CE logic could be a key enabler of a transition towards" (p.1). Providing an overall picture of the urban ecosystem is important. However, facilitating *communication and negotiation* amongst stakeholders is also key and currently missing. This could enable context appropriate responses to circularity.

In the context of the example of the inter-connected activities encompassed in the food system, we are truly dealing with complex intertwined issues that seem impossible to solve all at once – a context to which DT seems particularly suited.

As explained earlier, during the negotiation DT process, divergent and convergent thinking is used to identify potential solutions and strategies and also to understand better the various stakeholders' perspectives and needs. In order to understand what a 'sustainable city' means for its citizens, highlighting these perspectives and integrating them into the decision-making process is becoming key.

Figure 3 illustrates how the DT process connects to the UEA framework.

ECOSYSTEM FUNCTIONS				LMA food system FS activities	CAPITAL NEEDED TO PERFORM ACTIVITIES									
Production	Habitat	Regulation	Amenity		water	seeds	soil	Com-post	Org waste	Land tenur	New laws	funds	staff	Energy
Food biomass..	Green space..	CO_2 absorpt. ..	Recreation education											
				Production										
				Distribution										
				Processing										
				Education										
				Food waste management										
				T-Dde:Gap										



Max. sust. Yield; min. safe stand. Renew res.	Min critical Ecosyst sizes	Max. carrying capacity	Health standards/ valuable landscapes	LMA food system FS activities	water	seeds	soil	Com-post	Org waste	Land tenure	New laws	funds	staff	Energy	Total by pro-ducts
Cclusion negotiated % future Q to be prod. by FS					Conclusion of negotiations for next period										
				Production											
				Distribution											
				Processing											
				Education											
				Food waste management											
				New activities											
					% waste water reuse	Sust provision seeds	% soil regenerated	% compost used	% org waste composted	% of waste land re used	New land for green infrast	Funds generetd by add. value	% unemployement	% renew energy used	% by pro-ducts re-used
						Seed bank	% top soil created	No chemical fertilesers	% org waste transf into energ	Efficiency of land use crop rotation/ permaculture city principles		Nber CE projec funded by LMA	Innovative jobs for CE	% energy saved: reduced trans-port	Waste Management cost

Figure 3: Linking the DT Negotiation to the UEA of the Food System

Table 6 illustrates some of the ideas that could come up in the 'divergent phase' of a DT process, in relation to the protection of urban ecosystems functions.

		Ideas on how to increase…	Ideas on how to reduce…
Production functions	Food and biomass	Integrate (legally) UA in urban planning boost it	Food imports: scale-up high yield small-scale agriculture
	New seeds	Improve the collection of bio-seeds to organise seeds banks and decrease dependency on imports	Develop skills to collect seeds/ reduce dependency on imports
	flowers Medicinal plants	The creation of other production than food also needs to be valued to highlight all benefits of UA	Reduce vision of UA as only producing food
	Food security	Increase food security and sovereignty	Investigate different ways/ places/ technologies for UA
	Natural green space	A balance built/green spaces must be found e.g. through permaculture city concept	Landscape ecology to reduce proportion of built up saces
Habitat Functions	Space for food Product. green infrastructures	Better allocate land for UA so that food supply chains are shorter	Reduce waste-spaces that can't contribute to healthier city
	Reconversion of spaces for different uses	Avoid urban sprawl, foster infill development	Assess size, location, ownership, state of wasteland and id potential use in context of urban strategy
	Better balance in land use/ permaculture city	Balance in land-use to be found through permaculture principles/ crop rotation	Reduce trad. Urban 'zoning': id a strategy to allocate more ecological land use distribution
Regulation functions	CO_2 absorption	Growing food, increase greenery, foster absorption	Follow national strategy to reduce em./ increase growing vegetation
	Heat waves/ temperature regulation	Growing food/ greenery/ balances spatial allocation across the city	Organise green corridors/ UA sites across city
	Flood regulation	Green corridors; focus on species that act like 'sponges' / wetlands	Flood regulation - green corridors, focus on creating sponge areas
	Waste recovery for urban agriculture	Use organic waste to make compost/ recycle waste water	Reduce waste in landfill; educ./ innovation to value waste
	Regeneration of soils	Use agro-ecological principles to regenerate soils	Tackle priority neighbourhoods; training on soil regeneration
	Improvement of the city's ecological health	Green corridors and CPUL city productive landscape	Reduce polluted environment; tackle priority neighbourhoods
	Nature-based solutions for food prod. agroecology	Agro-forestry and other nature-based food production techniques	Reduce industrial-type of agricult. Training agro-ecological practices
Amenity/ information functions	Facilitating contact with nature	Re-introduce nature into the city / break the nature-city dichotomy	Facilitate access to green urban spaces
	Mental and physical health	Ensure provision of healthy food and Access to secure, calming green space	Encourage recreational practices and better diet
	Identity through food	Increasing awareness about food history	Reduce 'globalised food'; make local food affordable
	Cultural mix/ co-creation of urban places	Allocation of allotments to different cultural communities to encourage cultural exchanges and co-creation	Encourage social activities that facilitate cultural mix and social learning
	Learning about sustainability	Explore sustainability through practical projects	Develop pedagogical practices that move away from concepts
	Learning news ways of contributing to society	Learn how to transform wastes into valuable products/ inputs	Create innovative jobs through UA and waste valorisation
	Leisure: learning how to enjoy nature	Make green spaces for urban citizens' to enjoy and co-create	Provide facilities in green spaces to enjoy and want to stay in

Table 6: Brainstorming on potential Actions to Meet People's Needs Whilst Protecting UEF

For instance, with regards to contributing to regulation functions, UA activities combined with the organisation of green corridors could select plants that act as 'sponges' (e.. reeds) and could help with flood management. Similarly, growing-vegetation distributed around the city will contribute in a more geographically balanced way to CO2 absorption and can complement green corridors with more mature vegetation. In terms of citizens' involvement and improving urban-cultural identity, activities contributing to amenity/information functions could involve people presenting their 'successes' in terms of UA initiatives, highlighting the various benefits they bring.

In terms of objectives to be worked on iteratively, it would be desirable to focus on specific items rather than too broad subjects of negotiation that would impinge a productive DT approach. Our UEA framework indicates that two types of issues need to be negotiated: i) the target production for the various LMA Food

system activities to fill the identified Gap – which can include creating new activities/ jobs and ii) the allocation of by-products per activities to minimize wastes.

4. Conclusion

In this article, we have presented a set of urban ecosystems accounts which, in response to SEEA-EEA and MFA initiatives, offer a tailored approach that links the protection of ecosystems functions with circular cities objectives, is focused on the urban level, and encourages participatory processes. The construction of such framework and methodology shows how urban activities contribute to ensuring that urban ecosystems functions can perform and deliver goods and services to human communities but also help in maintaining a healthy balance (ecologically, socially and economically) within the city.

If achieving such balance takes account of some indicators - such as thresholds of renewability of certain forms of capital; minimum safe standards, ecosystems service potentials and capacity -, it also follows guidelines concerning the circularity of the city. Those, although based on the minimisation of waste and the re-use of by-products and waste, go into more detail when they have been translated into local regulations or when they come from national or European laws. They can, for instance, relate to human health and the choice of diet, hence influencing what food should be produced. They can also indicate that agricultural practices should not use pesticides and move towards agro-ecological practices – which influence the way in which organic waste is going to be re-used. What is variable is the way in which we innovatively and collectively decide to reform our practices.

We focused on the practical example of urban food production because this type of activities affects all of the UEF, directly concerns citizens' needs and welfare and their ability to take part in co-creating urban places, and because achieving food security at the metropolitan level is a key case study in exploring what a sustainable city is, with food production being core to urban resilience.

The article shows how, using both the UEA and a DT negotiating strategy, this approach could help the stakeholders of a metropolitan area in developing urban strategies focused on the circularity of an overall food strategy and on the maintenance of UEF (regulation, production, habitat and information functions) through a participatory urban governance system. The iterative and participatory characteristic of the approach reflects the fact that we are still trying to clarify what urban sustainability means for whom and that, consequently, urban planning is more and more concerned with *facilitating transitions towards urban sustainability and resilience*, in a complex adaptive manner.

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Foot Notes

[1] They show that despite occupying 2% of the land, cities nearly 70% of CO emissions, produce an enormous amount of waste andpollution, use 80% of energy and that 80% of the global demand for food comes from cities

[2] https://www.globalgoals.org/goals/11-sustainable-cities-and-communities/

[3] Urban permaculture is defined as permaculture practiced wherever the technological and social functions of the built environment
outweight the biological processes of nature (Hemenway, 2015, p.2).

[4] https://www.nationale-tadtentwicklungspolitik.de/NSPWeb/EN/Initiative/Leipzig-Charter/leipzig-charter_node.html

[5]See file:///C:/Users/User/Downloads/Greenbook%20Vf.pdf
e.g. Stockholm (2010); Bristol (2015); Lisbon (2020)

[6]A food system encompasses the full value chain of producing food for human consumption, from agricultural activities and other means, through transportation, handling, processing, storage, distribution and consumption, to organic – including human – waste management and disposal/ reintroduction into productive use (Ericksen 2008).

[7] http://habitat3.org/the-new-urban-agenda/preparatory-process/national-participa-tion/portugal/

[8] https://rural-urban.eu/living-lab/lisbon/live-cases

[2]