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The Circular Economy Model: from the Building Functional Reuse to the Urban System Regeneration

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Indice/Index

URBAN METABOLISM AND CIRCULAR ECONOMY INTERRELATIONS. ANALYSING THREE EXAMPLES OF EU-FUNDED PROJECTS

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Abstract

In Europe, the concepts of urban metabolism (UM) and circular economy (CE) have been made operational in several research projects and practical applications. However, although in the last years policy interests and scientific literature about UM and CE have been growing significantly, these concepts remain open, and their applicability is not univocal, especially concerning CE applied in urban systems. This paper analyses how three EU funded projects developed the interrelations amongst the fields of UM and CE. Different dimensions and scales of circularity were investigated, namely: (i) the potentials to create networking among different sectors to recycle waste at the regional scale; (ii) the importance of regenerating wastescapes; (iii) the accounting of resource flows that compose UM; (iv) the direct involvement of stakeholders in the management of resources.

Keywords: circular economy, urban metabolism, regenerative city

INTERRELAZIONI TRA METABOLISMO URBANO ED ECONOMIA CIRCOLARE. ANALISI DI TRE ESEMPI IN PROGETTI EUROPEI

Sommario

In Europa, i concetti di metabolismo urbano (MU) e di economia circolare (EC) sono stati resi operativi in diversi progetti di ricerca e applicazioni pratiche. Tuttavia, sebbene negli ultimi anni gli interessi delle politiche urbane e la letteratura scientifica su MU e EC siano cresciuti in modo significativo, questi concetti rimangono aperti e la loro applicabilità non è univoca, soprattutto per quanto riguarda l'economia circolare applicata nei sistemi urbani. Questo articolo analizza tre progetti finanziati dall'UE che hanno sviluppato le interrelazioni tra MU e CE. Sono state studiate diverse dimensioni e scale di circolarità: (i) le potenzialità per la creazione di una rete tra i diversi settori per riciclare i rifiuti su scala regionale; (ii) la rigenerazione dei paesaggi di scarto; (iii) la contabilità dei flussi di risorse che compongono i MU; (iv) il coinvolgimento degli stakeholder nella gestione delle risorse.

Parole chiave: economia circolare, metabolismo urbano, città rigenerativa

1. Introduction. The interrelations amongst Urban Metabolism and Circular Economy

Urban Metabolism (UM) and Circular Economy (CE) are two different approaches that share similar principles towards circularity, such as re-valorising local resources, flexibility, and adaptivity. These approaches can lead to sustainability if applied systemically: UM, mainly by considering the social and environmental dimensions, as instance deepening the stakeholders' involvement in decision making (Longato *et al*., 2019); CE, primarily by emphasising the economic and productive aspect (Geissdoerfer *et al.*, 2016).

On the one hand, Urban Metabolism (Ferrão and Fernandez, 2013; Kennedy *et al.*, 2007; Timmeren, 2014) can be defined as the combination of the material, energy, social, and economic flows, namely as "metabolic flows" (Geemente Rotterdam *et al.*, 2014). Deepening the study of urban metabolic flows means contributing to better management of the complex relationships among cities and their neighboring areas. UM is also including "the stock and flow of socio-ecological resources circulating in and through the urban system" (Elliot *et al*., 2019). On the other hand, Circular Economy (ARUP, 2016; European Environment Agency, 2016; Ellen MacArthur Foundation, 2017; Ellen MacArthur Foundation and Arup, 2019) "is based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems" (Ellen MacArthur Foundation, 2017). That means achieving efficient use of resources, both natural and social (Milos, 2017; Moreau *et al.*, 2017).

The main difference between UM and CE, which makes them complementary in urban studies, is that UM is strictly linked with the city dimensions, while CE is principally associated with companies' business models (Lucertini and Musco, 2020). Even if both approaches are recognised as relevant and as great promises for resources management and urban development from scientists and practitioners, they actually lack real widespread applicability and operativity, when they remain only at a conceptual level (Korhonen *et al.*, 2018). The concepts of UM and CE are still open, and their applicability is not univocal yet, especially concerning the principles of CE applied to urban systems. Thus, this is leaving still space for analysing and defining or understanding and experimenting with circularity in cities.

To overcome this knowledge gap, this paper tries to grasp the systemic nature of circularity and the possible application of its key principles by analysing three different EU-funded research projects, which have been developing and implementing diverse methodologies. Specifically, this paper does that by answering the following research questions: "What are the main aspects of urban regeneration and management which need to be addressed to achieve circularity? How selected EU-funded projects could teach the importance to involve stakeholders in co-creation decision-making processes related to circularity (e.g. urban living labs and *agorà*)?", and finally, "What are the limits and opportunities of circularity at the different scales and dimensions of urban regeneration and management?".

This paper, even if it has the ambition to show new interrelations amongst the fields of UM and CE – towards a more comprehensive concept of circularity in the urban sphere – and on their application in the context of scarcity of materials and territorial resources, shows also one main limitation. On the one hand, this study shows some innovative elements; for example, it firstly provides a review of UM and CE concepts by exploring their role in the today's debate about resource scarcity and environmental depletion. Secondly, it sheds light on some practical applications of the basic principles of circularity by presenting the key

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principles of three selected research projects, presented below. On the other hand, by exploring only three projects, this paper could overlook other important aspects that need to be addressed to achieve circularity. To overcome the limit to show only three projects, this paper presents, in the end, the European platform ECESP[1] (European Platform for the Circular Economy) and its mirroring Italian platform ICESP[2] (Italian Platform for the Circular Economy). These platforms constitute an important network of stakeholders, and a repository of best practices which could be transferred, to keep the discussion about circularity alive, operative, and to develop a national strategic agenda for circular principles.

The paper is organised as follows. It starts showing a general background of the problem, outlining the meaning of some important terms and concepts (Section 2). Then, the four key principles are identified (Section 3), and analysed through the three projects descriptions (Section 4). Finally, we discuss the results and the limits of the papers (Section 5), and we conclude suggesting future possible research paths (Section 6).

2. Background to the problem: the challenges of contemporary urbanization processes

As shown by Cognetti (2019), the traditional urban shapes, spatial categories, planning theories, and fixed scales are, at this point, inadequate to interpret the complexity of contemporary urban spaces, which are crossed by material and immaterial flows of goods, people, energy and information, in continuous movement. Global population and urban areas rapidly grow, and, for achieving that, they need a growing amount of resources: "demand for water, energy, and food is increasing, driven by a rising global population, rapid urbanization, changing diets and economic growth" (Vanham *et al*. 2019). Thus, ever-increasing contemporary urban challenges reflect this situation of generally high demand and related scarcity of finite resources and the exceeding of the ecosystem boundaries. Climate change, waste production, soil contamination, and air pollution are some of the main environmental challenges related to that. Moreover, if we include land surfaces and soil quality in the categorization of scarce or wasted resources which are consumed daily by urbanization processes, wastescapes (Amenta, 2019; Amenta and Attademo, 2016; Amenta and Qu, 2020; Amenta and van Timmeren, 2018) can represent the spatial outcome of the linear processes of land consumption. Thus, they require new and urgent management strategies.

Several EEA reports (2011; 2016; 2019) showed that the high rate of resource consumption and the consequent unmanageable waste generation are among the main causes of nature and ecosystems depletion. In this context, waste should be considered as a direct result of a deeper problem embedded in urban societies, where resources are extracted, transformed, used and disposed of - following a linear model - in faraway places, without environment awareness and consequently jeopardizing economic stability and humanity's survival (Ghisellini *et al.*, 2014). Resource consumption is, indeed, mainly due to the increasing population's needs, and it is strictly interconnected with worldwide urbanization and climate change; thus, pushing the limits of the carrying capacity of the Earth it is one

[1] See more at: https://circulareconomy.europa.eu/platform/en. Last accessed: 30 March 2020.

[2] See more at https://www.icesp.it/. Last accessed: 30 March 2020.

among the most urgent demands which we will face in the next years (Yigitcanlar and Dizdaroglu, 2015). To deal with these challenges, the two approaches of UM and CE have been receiving increasing attention so far, towards the implementation of sustainable and circular urban environments.

Over the last few years, the number of publications in both scientific and in grey literature in UM and CE has consistently increased. The Urban Metabolism approach is based on the metaphor which compares the city to a living organism in which streams of resources support life (Kennedy *et al.*, 2007; Thomson and Newman, 2018; Wang *et al.*, 2018) with inbound and outbound flows, and inevitable waste generation, as it happens in all-natural living entities. The UM main goal is understanding the actual functioning of cities towards the design of more sustainable urban systems, which could eventually be based on a circular metabolic model, in contrast with the current one. UM aims to implement a new approach that is significantly different from a linear metabolism which characterises unsustainable cities which need high inputs of virgin resources to function. Resources are continuously extracted and transformed to produce goods and services, and then some of them are dumped out as negative externalities (waste). Thus, achieving circularity means essentially to work on waste, aiming to reduce it to zero (European Commission, 2014), or, when not possible, transforming it into secondary raw materials. Secondary raw materials are substances that were formerly considered as waste, but that has the potentiality to become a new type of resource, by remaining into the urban metabolic system as long as possible (Ferrão and Fernández, 2013). This implies the necessity to reconsider waste as an innovative resource to be valorised. The rationale behind that, it is considering what is useless for someone as a potential new resource for others. This can be applied not only at the level of the material waste but also in relation with possible spatial waste, such as the areas that reached the end of their life cycle and which can be reinterpreted with creative reuse processes, and, in this way, starting new life cycles: the regeneration of the westscape mentioned above. For more details on UM the reader can see also the following literature: Newman (1999); Sahely *et al.* (2003); Kennedy *et al.* (2011); Rapport (2011); Pincetl et al. (2012); Agudelo-Vera *et al.* (2014); Voskamp *et al.* (2017); Hoekman and von Blottnitz (2017); Cui (2018); Marin and de Meulder (2018); Thomson and Newman (2018).

Circular Economy is an emerging concept considered as another possible and more sustainable option in contrast with the actual linear model of growth (de Ferreira and Fuso-Nerini, 2019) and "a sustainable alternative to the actual economic system" (Silva *et al.*, 2020). The CE approach is well-know and largely defined (Kirchherr *et al.*, 2017), it is referred to as: "an economic model aimed at the efficient use of resources through waste minimisation, long-term value retention, reduction of primary resources, and closed loops of products, product parts, and materials within the boundaries of environmental protection and socio-economic benefits" (Morseletto, 2020). Thus, CE provides an alternative rationale of material flows that are cyclical, following closed loops, and designed to overcome the traditional one, based on an 'extract-produce-use-dispose' approach. The concept of CE, discussed and launched by the European Commission through the CE package and the CE Action Plan (European Commission, 2014; 2015; 2020), recently gave strong support to the waste prevention and resource management strategies.

The CE approach has been made operational mainly through the Rs frameworks. Starting from the three Rs framework: Reduce, Reuse, Recycle, it evolved to the nine Rs framework: refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose,

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recycle, and recover. These "R frameworks" are based on a similar action hierarchy that moved from the preferred option to the poorer ones (Potting *et al.*, 2017). It means that CE can be made operative through the application of a set of actions, which have been developed for materials (i.e. manufactured objects), but that under such perspective, can be understood and also applied at the city level, operationalising UM. For more details on CE the reader can see also the following literature: Andersen (2006); Murray *et al*. (2015), Lieder and Rashid (2016); Witjesa and Lozanoa (2016); Smoll *et al*. (2017); Kalmycova *et al*. (2018); Velenturf *et al*. (2019); Schröder *et al*. (2020).

Cities are one of the main focus of attention for planners, architects, and politicians towards the shift to improved sustainability; economic, social and environmental benefits can be achieved through the application of circularity principles, but this can only happen if cities are designed and managed differently and if the resources employed are reused and repurposed maintaining their value over time (Ellen MacArthur Foundation and Arup, 2019).

In a world in which cities are called to be the front line toward the sustainability and challenges as urbanization, climate change, and resource depletion, UM and CE are two effective possibilities. Circularity is a shared concept supported and sponsored by the international community and well-accepted also by the economic sector (European Commission, 2015; 2020). Urban Metabolism and Circular Economy can be read in a complementary way, linking applicative actions to the urban flows of materials to achieve the circularity of resources. In such a perspective, they can guide and design a new urbanization process that could be more sustainable than the current one. It should be able to transform urban spaces, practices, and consumption from linear to circular, to limit the urban greed of virgin resources, and protect environmental and ecosystem services. Circularity and thus UM and CE approaches need changes in the design of city-scapes, in institutional processes, and also in everyday habits. The three projects, as described below, have been addressing these aspects experimentally and as an innovative manner.

3. Implementing circularity in the urban environment: key principles

This paper builds on the authors' experience-based research into EU-funded programs in different contexts, scales, and degree of deepening on the understanding of resource flows and their management, and stakeholders' involvement in the implementation of circular urban environments. This constitutes one of the motivations of the selection of the projects presented in this paper. The second motivation for these projects' choice is their different scale of application. "*Opportunità*" is an award-winning project that shoving circularity principles at the regional scale, while the two H2020 – "REPAiR" and "Urban_WINS" – are the only two projects financed by the call "WASTE-6a-2015", showing the paths towards circularity at European scale. The third motivation is to be searched in the various contexts, in the selection of different resource flows, and dimensions of circularity that they address. An analysis of these three projects was made to identify and explore the key principles of the projects' processes and their results. In these projects, several aspects of circularity are addressed; they could all contribute to achieve a holistic understanding of the matter. This paper identifies key principles for reading and analysing them, deriving from the base knowledge which the authors already had about these projects. This is composed of four main aspects, which have been identified as the main features which the projects address: (i) closing the loops of resource flows at the regional scale, as in the project of the

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Veneto Region namely "*Opportunità*"; the importance of (ii) regenerating wastescapes Europe-wide, which is one of the focuses of the H2020 project "REPAiR"; (iii) the accounting of resource flows – which compose UM – as in the H2020 project entitled "Urban_WINS"; finally the (iv) direct involvement of stakeholders in the management of resources, that is a central element in all three projects. These key principles were useful for analysing and describing the projects and systematizing their results, which are discussed to make them available for further research.

The three selected projects are interpreted as best practices that could contribute to filling the knowledge gap introduced above, and their analysis aims to answer the research questions mentioned above. Specifically, the first one is a small scale (regional) EU-funded project named "*Opportunità - sinergie circolari per un mercato efficiente. La formazione e le reti per l'acquisto il recupero e il riuso*" (the title translated in English would be: "Opportunities - circular synergies for an efficient market. Training and networks for purchasing, recovering, and reusing"). This project focused on the potential to close the loops of resource flows through the actors' networking – belonging to different sectors – to recycle waste in the Veneto Region. The second is a European Horizon 2020 project, entitled "REPAiR: Resource Management in Peri-Urban Areas. Going Beyond Urban Metabolism"[3]; it outlines, among its different findings regarding closing the loops of the material flows, also the importance of the regeneration of wastescapes (REPAiR 2018a). Finally, the third one is also a Horizon 2020 project named "Urban_WINS – Urban metabolism accounts for building Waste management Innovative Networks and Strategies"[4], which has been focusing on account of resource flows and the direct involvement of stakeholders in the management of resources (Longato *et al*., 2019).

It is interesting to notice that these three projects have different approaches, "*Oppurtunità*" and "Urban_WINS" work more on managerial aspects and with the stakeholders' involvement, while "REPAiR" is more focused on the spatiality of the material flows even if the other aspects are also explored.

4. Analysis of the projects and their key principles

4.1. The regional project "*Opportunità*" (Veneto Region)

The project "*Opportunità*" – differently from the H2020 European projects REPAiR and Urban_Wins – was a regional project, thus, with more circumscribed objectives, and with the involvement of a more homogeneous group of stakeholders, indeed they are coming from the same geographical area and with related interests. *Opportunità* focused only on the Veneto Region, and more deeply on the Padua area, where a strong engagement of the administration has guaranteed the right conditions to carry out the project (i.e., provision of spaces for meetings, technical and political experts, direct involvement, etc.).

The project, which ended in 2019, had a duration of twenty-one months; it was financed by the European Social Fund (ESF) through the Veneto Region[5]. One of its main goals, in line

[3] For more info on this project see the 'REPAiR' webpage: http://h2020repair.eu/

[4] For more info on this project see the 'Urban_WINS' webpage: https://www.urbanwins.eu/

[5] See more at: https://www.regione.veneto.it/fse-fondo-sociale-europeo. Last accessed: 31 March 2020.

with the first of the key principles, was to close the loop of the resource flows. The project's innovative idea was to achieve this result by creating of stakeholders' networks among different sectors, to recycle and reuse waste at a regional scale. The involved stakeholders were directly and indirectly interconnected, coming from the private and public sectors, but also the municipalities. These actors were linked to each other by their interest in a specific flow of resources, where the waste of one of them could become the secondary raw materials for another one. According to the Veneto Region's main priorities (Regione Veneto, 2014), this project focused on several resource flows, like building materials, clothes, and food. The most developed theme for which interesting results were presented was the agri-food system; specifically, the topic of food waste and the issues related to the production and use of compost were deepened in this project. In the Veneto Region, the agriculture sector is well developed, but it is composed of a multitude of small and medium farms that have difficulty creating a critical mass to impact the market and achieve innovation. The project "*Opportunità*" implemented an approach organised in three steps - as outlined right below - based on the direct comparison and discussion of different but relevant sectoral stakeholders, such as farmers, and farmers' associations, caterers, companies of waste disposal and transformation, and municipalities. Within the framework of the project "*Opportunità*" several participatory meetings were developed. In the first step, homogeneous groups of stakeholders (i.e., farmers and farmers' associations) have been invited to discuss their situation and problems about the implementation of circularity principles, with some experts. In the second step, stakeholders coming from different sectors, but with correlated problems (i.e., actors working on the same supply chain) have been encouraged to discuss together to find some contact points and clearly define the barriers or threats to circularity. Finally, in the third step, all the stakeholders have been called to construct a possible solution process and identify implementable actions, as outlined below. Moreover, the network co-created both a path to understand and disseminate the CE approach and a way to define a roadmap to operationalize and apply these approaches to the agriculture and food sector. The main project goal was to continue the exchange of technical and applicative information implementing joint activities, to implement eco-innovative solutions and capacity building. The project incentivised the collaboration between different private companies, which identified and defined innovative methods and patterns with the direct support of research centres and local and regional administrative bodies.

The network, considering the Veneto agri-food system, identified three main issues (related to flows) to investigate: soil conservation and soil consumption; organic waste collection; and fight against food waste through recovery and donation of food surplus. Considering soil consumption, the Veneto Region is one of the Italian regions with the highest concretisation. However, the Regional Law 14/2017 has the objective of preserving the soil resource – up to zero consumption by 2050 – promoting actions such as urban regeneration, the redevelopment of the existing building heritage, and prospecting a slowdown in consumption speed of the soil (hectare/year ratio). In that regard, the network objective was to increase citizens' awareness about it, and force administrations to reverse this trend. They have proposed actions to involve the citizens, and thus, to disseminate and discuss direct and indirect problems due to soil consumption. Instead, about the soil conservation issue, the network's main goal was to increase the organic substance content of soils, allowing to compensate for the carbon dioxide (CO_2) emissions, as well as improving the

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fertility of agricultural land. That can be achieved by adopting sustainable management practices of the soil, such as conservative agriculture. In that way, it is possible to ensure production stability, create green jobs, and mitigate the effects and risks of climate change. Moreover, the agriculture sector stakeholders recognised that many issues and dangerous dynamics are related to air pollution, climate change, and specific soil emergencies: desertification, erosion, hydrogeological instability, etc. This is partly due to the transformation that took place in the sector, which promoted intensive and large-scale agriculture, at the expense of sustainable forms that could have guaranteed the maintenance of natural resources, the provision of ecosystem services, good quality of the environment and biodiversity. Consequently, they intended to reverse this trend through the dissemination of information, explaining alternative soil management, and asking support to local and regional authorities in the form of incentives and limits for mineral fertilizers.

The second issue was about the separate collection of the organic fraction of municipal solid waste. In that context, organic waste can be considered as secondary raw material, because, through composting, wastes are transformed in natural fertilizer to be used in place of the mineral ones. The use of compost to improve the quality of soils allows reducing the CO2 emissions deriving from the chemical production of mineral fertilizers, as well as to produce fuels from renewable sources, with economic and environmental advantages. The good practice of composting - that could be supported by the whole network - was defined as a circular from several aspects. Firstly, it could connect several economic sectors in which the waste of one is a nutrient or an energy source for another. Secondly, it could be considered a renewable and sustainable source of organic nutrients. Thirdly, it could improve and stabilize the physical structure of the soil, by acting on the porosity, the degree of aeration and the water and carbon retention capacity; finally, it could avoid the use of non-renewable organic materials and reduce the amount of energy necessary for waste management and the production of chemical fertilizers. The network proposed actions about the creation of a "the community compost" from which farms can obtain and use directly; creation of purchasing group of small farms to reduce transport costs of compost; creation of a work table between the representatives of the local administration, research center, organic waste operators, and farmers to have certificated biological compost and to solve or overcome normative and administrative problems.

Finally, the third issue was about the fight against food waste, through recovery and donation of food surplus. The current food production system presents several limits and problems (Annunziata *et al.*, 2020) and a more sustainable model is required to respond both to the growing demand of food and the containment of organic waste, which is the waste typology with higher production in tons per years (ISPRA, 2019). In that context, the network's objectives were to reduce food waste, both by enhancing the current service of food recovery based on canteens donation and by extending it to caterers, through the activation a food recovery system directly in the farms, where, very often, products might be not collected just for cost issue.

In that context, the creation of the network is the key aspect to close the loop of resources, it works on some specific flows on which can develop eco-innovation. In that way, the innovative network was able to join different but interrelated sectors of the traditional supply chain, and identify and integrate new sectors, thus creating alternative and eco-innovative supply chains and actions. The whole stakeholder network recognised that

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having the possibility to directly discuss with all the supply chain actors is the principal aspect of implementing the CE approach.

4.2. The H2020 "REPAiR" project

Among the main objectives of the project "REPAiR" [6], there is the development of Eco-Innovative Solutions (EIS) and strategies in relation to waste and resource management in six peri-urban areas across Europe. Following the second point of the above-mentioned key principles, REPAiR is also aiming at regenerating wastescapes Europe-wide (for more literature about REPAiR see: Remøy *et al*., 2019).

The Horizon 2020 call "WASTE-6a-2015" – through which the project REPAiR has been financed – stated that "[Eco-innovative Solutions (EIS) are] "demonstration, at an appropriate pilot scale, and market replication, of integrated eco-innovative cost, and energy-efficient technologies, processes and/or services for waste prevention, treatment, enhanced collection, recycling and recovery of valuable high-grade materials from waste", REPAiR aims to develop EIS and integrate them into territorial Strategies. As defined by REPAiR, "an Eco-Innovative Strategy is an alternative course of action aimed at addressing both the objectives and challenges identified within a PULL and developing a more Circular Economy in peri-urban areas" (REPAiR, 2018b).

REPAiR - a project still ongoing until December 2020 – studies the two pilot regions of Amsterdam and Naples Metropolitan Areas, and four follow-up regions namely Ghent, Łódź, Hamburg, and Pécs, respectively located in The Netherlands, Italy, Belgium, Poland, Germany, and Hungary. Furthermore, REPAiR has been developing a tool, namely, "GDSE – Geodesign Decision Support Environment"[7]. The GDSE is an open-source web-application that models the Geodesign process, integrating GIS technology and MFA, and aimed at help users co-develop EIS in Peri-Urban Living Lab workshops (Arciniegas *et al.*, 2019).

In line with the principles of CE and UM, the REPAiR project's approach aims to understand and manage material and territorial waste – the latter are defined "wastescapes" – acting as innovative resources. By analysing the structure and functioning of the European resource management systems – which are different case by case – this project studies the specific relations between the waste flows and the spatial structures of the six peri-urban areas investigated. Thus, it focuses on several waste flows such as construction and demolition waste, and organic waste. By also deepening the study of the impacts of waste management systems on the environmental and spatial quality of the case studies, REPAiR focuses on the spatial impacts that the infrastructures for waste management and disposal could have on the landscape such as the former landfills, and incinerators.

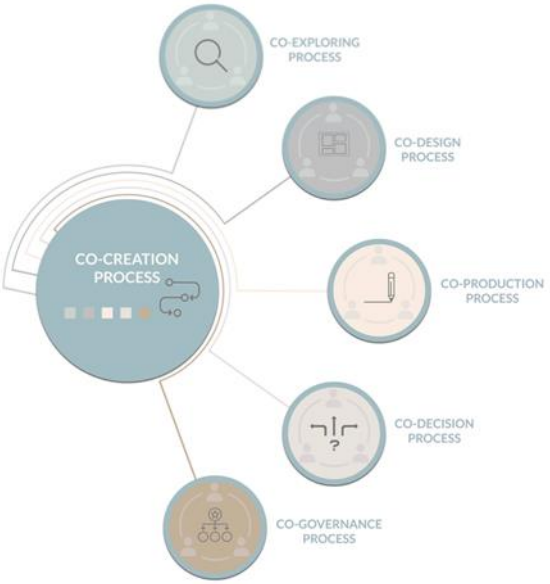
REPAiR adopts an experimental way to involve all the relevant stakeholders in the co-decision processes related to waste management; it does that for each case identifying the following actors: regional authorities, municipalities, professionals operating in the field of circularity, citizens' associations, students and researchers), by implementing six "Peri-Urban Living Labs" (PULLs) - one in each focus area of the project - which are physical

[6] For more info on the REPAiR project see the project website at: http://h2020repair.eu/

[7] For more info on the GDSE see the REPAiR webpage: http://h2020repair.eu/

and virtual environments where to develop, test and implement eco-innovative strategies and solutions in co-creation sessions. Moreover, the PULLs are understood in REPAiR also as "Knowledge Transfer Platforms", that means environments where to explore the transfer of the Eco-Innovative Solutions co-developed in the project from case to case – experiencing in this way the different degree of transferability of solutions – and where to investigate how the solutions are modified since they "travelled through the relational space of the networked living labs" (Dąbrowski *et al.*, 2019).
REPAiR focuses principally on the stakeholders involvement and networking and the implementation and testing of (eco)innovations for closing the loops of resource flows. The project is spread on six European peri-urban territories, thus involving six countries, where the same amount of Peri-Urban Living Labs (PULLs) have been implemented (REPAiR 2018c; 2017; Amenta *et al.*, 2019) to guarantee the stakeholders' engagement and eco-innovation creation. REPAiR has been establishing a methodology to carry out the PULLs, where eco-innovative strategies and EIS for material waste and wastescapes have been elaborated and finally tested, by following a co-creation process. The latter has been implemented in the PULL workshops, and organised following five phases: Co-Exploring; Co-Design; Co-Production; Co-Decision; Co-Governance (Fig. 1).

Fig. 1 – The five phases of the Co-creation process of the PULLs: Co-Exploring; Co-Design; Co-Production; Co-Decision; Co-Governance.



Source: Amenta, 2019. Beyond WASTESCAPES Opportunities for Sustainable Urban and Territorial Regeneration. Delft, The Netherlands: TU Delft Open, p. 109. Graphic by V. Vittiglio.

The 'Co-Exploring' phase focuses on denoting a "common understanding of the territory", conceived by involving numerous stakeholders such as researchers, and experts working in the circularity field, or in the same geographical area. Moreover, the key resource flows (for instance, construction & demolition waste, organic waste) - which represents the most important streams for each case study - are selected at this stage. Finally, in this first phase, the main challenges/problems, as well as the objectives are defined. The second phase, namely "Co-Design", is dedicated to the appraisal of the status quo to define EIS. Subsequently, in the "Co-Production" phase, the EISs are further developed together with the Eco-Innovative strategies to implement the transition to more circular models in peri-urban areas. The "Co-Decision" phase is useful to assess the EIS efficiency and their transferability to other contexts. Moreover, this phase explores the agreements and conflicts between the different interests of stakeholders involved to activate future local development by influencing the decision-making process through the implementation of co-creation. Finally, the last phase, called "Co-Governance", is about defining decision-making models based on co-creation, which could be transferable to further cases (Amenta *et al.*, 2019; REPAiR, 2018c). The PULL methodology has been implemented case by case, thus being site-specific. As an instance, the PULLs organised in the two Pilot cases of Amsterdam and Naples, even if they have been running in parallel, they resulted in being quite different from one another, with regards to the numbers and kind of participants, duration and number of meetings and workshop organised, and finally about the activities which have been carried out (Amenta *et al.*, 2019; REPAiR, 2018c). In fact, the organization of the various phases depended very much on the kind of stakeholders involved in the different governance structures, and on the importance of their involvement and contribution to the regeneration of the peri-urban areas. Through the PULL methodology, REPAiR assured the broad participation of stakeholders in all the design phases starting from conceiving, then developing, and finally producing and testing a project idea. Therefore, in the PULLs, through co-creation, the ownership of the ideas belongs to all the stakeholders involved, then their empowerment - for the possible implementation of the solutions developed - is possible (Amenta *et al.*, 2019). Starting from the premises of the European directive on waste (EC 2008), one of the innovative results of the project is the identification of a new kind of "waste" which includes neglected built and unbuilt (peri)urban parts defined as "wastescapes", formerly introduced in REPAiR as "Wasted Landscapes" (European Commission, 2016). Wastescapes have been conceived as innovative resources to achieve a more circular economy and defined according to a double meaning. They include at first the category of "drosscape" (Berger, 2006a, 2006b), that contain polluted lands, brownfields or 'land in limbo' in a waiting condition (De Martino, 2016); second, they could be "operational infrastructure of waste" referring to the new "waste geographies" defined by the facilities for waste management and disposal and their impact on the territory (Brenner, 2014; de Leo and Palestino, 2017; O'Shea *et al.*, 2016; REPAiR, 2018a).

Wastescapes can be effectively investigated and re-designed within the PULLs through the above mentioned five-phases process of "Co-creation". The latter allows addressing multiple problems and perspectives at the same time, by involving a large number of stakeholders with different expertise or interests. In this way, the economic, social, functional, ecological, and technological aspects related to wastescapes could be deepened. In fact, wastescapes are often the result of a sectoral approach to the territory's spatial organisation. Thus, the regeneration of wastescapes - in order to be able to affect their

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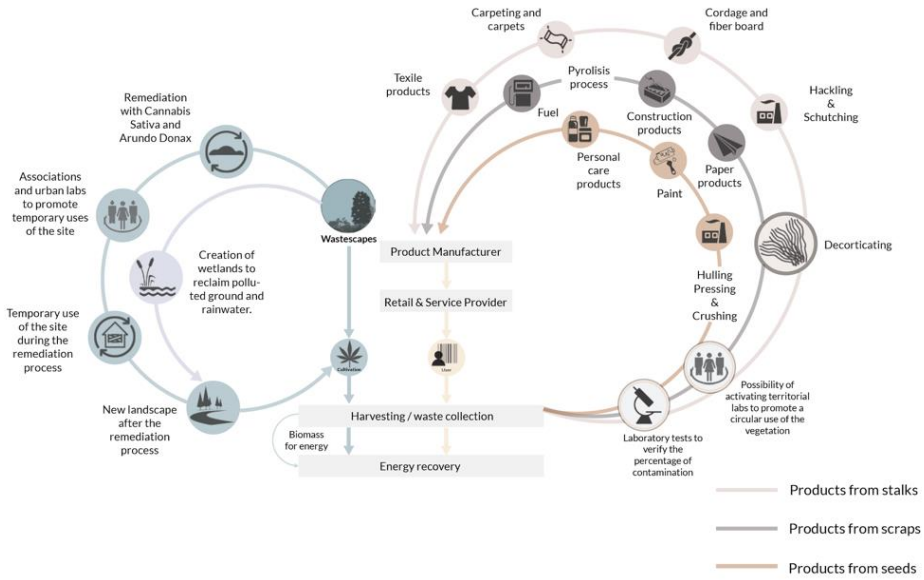
dysfunctional urban metabolisms positively - should aim to be systemic and inclusive by involving, not only urban planners and architects, but also municipalities, regions, and citizens, towards the establishment of long-term and shared visions (Amenta, 2019).
One example of the outcomes of the REPAiR PULL of Naples is the EIS named "RECALL: REmediation by Cultivating Areas in Living Landscapes through phytotechnologies" [8] which is meant to design a regeneration process of polluted wastescapes (Fig. 2).

Fig. 2 – The Eco-Innovative Solution, namely 'RECALL'. Based on the graphic of Ellen



MacArthur Foundation https://www.ellen-macarthurfoundation.org/

Source: UNINA Team, 2018, Deliverable 5.3, p. 44. Graphic adapted by V. Vittiglio, in Amenta 2019, p.88.

The main objectives of this solution are: firstly, the reclamation of polluted soils and water (along with Regi Lagni Rivers); secondly, the restoration of the former agricultural tradition (e.g., hemp cultivation or other local crops) to promote new forms of CE for the wastescapes located into the Metropolitan Area of Naples; finally, the improvement of the employment situation involving the local community in the agricultural activities. This

[8] This Eco-Innovative Solution is developed within the framework of the Horizon 2020 project REPAiR (Grant Agreement number 688920). Moreover, it is also part of the PhD Thesis of Valentina Vittiglio, "Dottorato in Architettura", 32° cycle financed within the framework "Programma Operativo Nazionale Ricerca e Innovazione 2014-2020 Fondo Sociale Europeo, Dottorati Innovativi con caratterizzazione industriale." For more information on this solution, see also: Russo et al. 2019.

solution implements phytoremediation to restore polluted soils by using local crops which have the capacity of absorbing heavy metals from the soil (such as hemp) (see: Deliverable D5.3 Eco-Innovative Solutions Naples – REPAiR, 2018b). This is done as a circular alternative to the usual remediation processes from both an economic and an environmental point of view. In fact, through the use of these techniques, it is possible first of all to clean the soil by heavy metals locally; secondly, biomass is produced and it can be used for different purposes. In these ways, new forms of the circular economy for wastescapes, with the involvement of local communities, are triggered, by restoring the ancient agricultural tradition of cultivating hemp in Campania Region (Amenta, 2019). Finally, by producing hemp, it is possible to realise many products that can be commercialized (Linger *et al*., 2002). In addition, compatible uses can be imagined for the territory while the restoration process is developed. In REPAiR, the key principles outlined above are interwoven, and their systemic implementation assures the innovative approach of the project. For example, stakeholders played a crucial role in mapping wastescapes and the co-exploration phase of the Living Lab; indeed, they contributed with their specific knowledge of the territory to the identification of the key challenges of the case study investigated, pointing out the areas of interest for which appeared to be more urgent to develop eco-innovative solutions and strategies.

4.3 The H2020 "Urban_WINS" project

"Urban_WINS" [9] – started in 2016 and finished in 2019 – was a H2020 project, it was mainly devoted to analyse the accounting of urban resource flow and the direct involvement of stakeholders in the management of resources. Urban_WINS was a complex project, based on a broad consortium including twenty-seven partners, and composed by several (and consequential) activities. The project had eight pilot cases: Turin, Cremona, Albano Laziale, Pomezia, Bucharest, Sabadell, Manresa, Lleira, located in four European countries, and respectively: Italy, Romania, Spain, and Portugal. Moreover, the development of Strategic Urban Plans has been based on improved knowledge of the factors that influence the Urban Metabolism (UM) of cities, through a continuous stakeholders' engagement (European Commission, 2016b). The project was aimed to study the UM concept as a new approach to urban management and planning. Its main objective was to develop and test methods for designing and implementing innovative and sustainable Strategic Plans for Waste Prevention and Management, to enhance urban environmental resilience. These plans, one for each pilot city, are innovative for both methodology and content. Methodologically they can integrate experimental scientific data and stakeholders' knowledge and opinions through a constant and co-created participation engagement. Content is also innovative because the identified actions, policies, and strategies consider sustainable and resilient principles in a structural way asking an institutional, procedural change and are based on eco-innovations and best practices. The plans were defined primarily in three moments of stakeholders' engagement. The first one was developed into the *Agorà*, where they were called to create, discuss, and select specific actions, in a shared

[9] UrbanWINS benefited from the support of a European Advisory Board (EAB), consisting of 20 high-level representatives from EU decision-making bodies, regulatory bodies and other stakeholders from the waste sector. See more at: https://www.urbanwins.eu/eab/, last accessed: 31 March 2020.

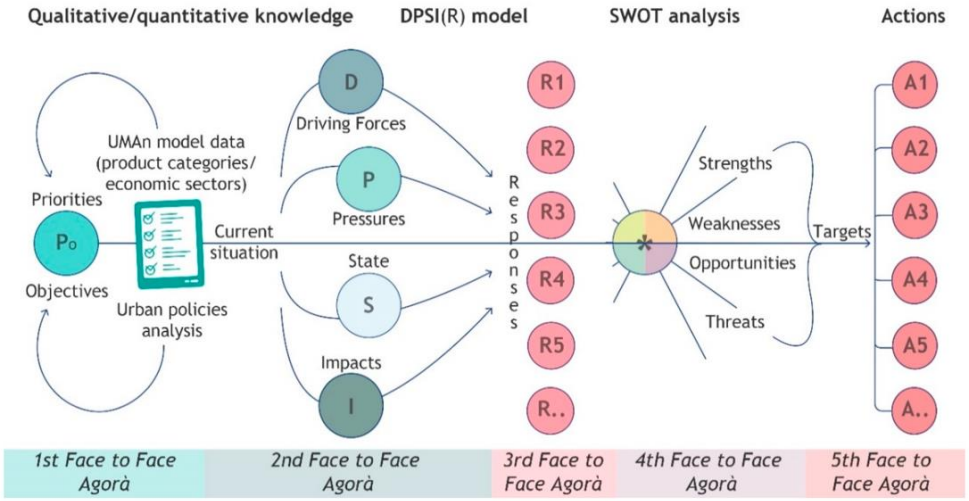
and participative way. Then, in the second one, the selected actions were further addressed within the municipality among the administrative city's sectors to understand their economic, legal, and practical feasibility. Finally, in the last moment, the plans with all the remaining actions were presented again into the *Agorà* for a last public legitimation (De Marchi *et al.*, 2016). Following the UM approach, Urban_WINS developed a methodological framework to support the municipalities to create Strategic Plans able to overcome the limits of the linear economic model, and the criticalities related to monodisciplinary and sector-by-sector approaches, by building on an integral vision that makes the best out of different disciplines and tools (Longato *et al*., 2019). The methodological framework, developed by Urban_WINS, is based on qualitative analysis of stakeholders' objectives and resources, and quantitative analysis for the calculation of material flows. On the one hand, the qualitative analysis was developed considering Stakeholders' perception and knowledge. On the other hand, the quantitative model applied in the project, called the 'Urban Metabolism Analyst' (UMAn) (Rosado *et al.*, 2014), is based on the Material Flow Accounting (MFA) methodology. MFA is a tool developed and used to quantifying material flows and stocks, "it is a mass balance approach and traces the flow of materials through socio-economic systems from their extraction in agriculture, forestry, and mining to their end-of-life discharge to the environment as waste and emissions" (Krausmann *et al.*, 2017). The use of these two different sources of knowledge was proposed to inform decision-making, both with stakeholders' and citizens' perceptions and interest, as well as with quantitative data about all the sectors, materials, and products that mainly affect the urban system. According to the Urban_WINS approach, stakeholders' engagement is an essential element that was developed into the Urban *Agoràs*. These are physical and virtual spaces [10] established by the project, where municipalities, stakeholders, and citizens discussed together on several urban issues, like waste collection, awareness waste campaign about waste, restoring abandoned areas and so on (Vasconcelos *et al.*, 2017). These spaces are also the places in which city actors, through comparison, can co-define city objectives and priorities and co-create actions to achieve them. The participatory process was carried out following a defined and shared protocol that implicated various meetings, named "Face-to-Face *Agoràs*", and involved policy-makers, relevant stakeholders (e.g., industry and professional associations, private and municipal companies, local authorities, citizens, etc.), and citizens. These meetings have been designed to develop specific activities and achieve specific objectives (Fig. 3).

This method had the objective to organise and manage jointly the several meetings, but at the same time ensuring flexibility to cities to tailor the activities according to their own situation, characteristics, and needs. All the information and suggestions coming from the meeting were subsequently analysed, verified, and sometimes integrated by the decision-makers or experts of the municipality. In the first *Agorà*, the participants, through the help of collected data and carried out analysis, have defined cities' priorities and objectives. In the second and third *Agoràs*, they were called to identify - using the DPSIR framework (Driving force; Pressure; State; Impacts and Responses) - problems and possible solutions. In the fourth *Agorà*, the possible solutions were analysed and discussed with the SWOT

[10] See more at: https://www.urbanwins.eu/online-agora/.

approach. Finally, in the fifth *Agorà*, the selected solutions were transformed, and the actions were co-created [11].

Fig. 3 – The structure of the five meetings of the Urban_WINS participatory process



Source: Longato et al., 2019.

Following this methodology, the project has been able to ensure the systemic involvement of stakeholders and citizens into the whole decision process (Tsoukiàs, 2007). The latter started with the problem structuring, then there was the identification of the objectives and priorities, thus the final decision of what actions to implement. In that way, the involved actors could enhance their knowledge about the waste issues, but, at the same time, by discussing with the others, they could also understand different positions and points of view, and they could face the limits of available resources and normative barriers. Moreover, the methodology, with its various phases and tools, assured a continuous comparison and constant interaction among several preferences, expectations, technological capabilities, and economic possibilities; furthermore, it has been able to stimulate the actors to imagine and create real innovative eco-solutions, that led to also identifying a roadmap with strategic directions for waste reduction and management, in a medium and long term perspective.

The final results of these processes is the co-created eco-innovative actions, that have been used to create the plans. The actions can be grouped in four main categories: the first one is related to the rational use of resources (food, water, energy, and soil); the second, is referred to sustainable mobility and CO_2 reduction; the third, regards the development of new sustainable sectors and local economies; and the fourth, it is linked to the waste prevention and management. In the four italian cases (Cremona, Turin, Pomezia, and

[11] For further explanation of Urban_Wins methodology see: Longato et al., 2019.

Albano Laziale) just three of these categories were considered. Indeed, no one developed and selected actions that may fall into the category of sustainable mobility and CO_2 reduction. This was the case because all the four cities claimed to have already implemented measures and policies focused on mobility and CO_2 reduction in other specific plans (i.e., urban traffic master plan, secap, etc.). Thus, they considered those categories as already achieved.

The number of actions selected by the Italian cases was quite different: Cremona selected the higher number of actions, namely nineteen; then, there was Pomezia with the selection of ten actions, and then Turin and Albano Laziale with the lower number of actions, namely only eight actions. These actions worked principally on five flows: urban waste; energy; water; food; and soil. In the majority of the cases, these actions impacted on more of one flow at a time. This means that, actually, resources are usually interconnected and that acting on one of these fatally lead to consequences on the others (trade-off) (Simpson and Jewitt, 2019). The only flow that cities considered in some cases separately were the flow of food, which was considered alone in eight actions, and the flow of water, which was considered alone just in two actions.

In that count, urban waste was not considered because in all the actions it was treated as a composite entity formed by plastic, paper, organic, metals and other materials. Furthermore, actions directed to the energy flow were not designed, and the impacts on that flow were always seen as an indirect consequence of some actions on other flows. Probably, like for mobility and CO_2 reduction, stakeholders and administrations believed (sometimes unconsciously) to have already acted and implemented actions to impact this flow and further efforts do not have priority. This is confirmed by the fact that, in these cities, several energy policies have already been implemented in the Municipal Energy Plan. These data show how stakeholders and municipalities are more concerned and interested in urban waste and food issues. An explanation could be given by the fact that these two topics are easy to be understood and everybody has experience with them.

In that project, the key elements are strictly related and play an innovative role. Stakeholders' engagement underlies any project activities, while any decisions was supported by the resource flow accounting.

5. Discussion

Increasing urbanization requires a constant resources demand that - to be sustainable - needs adequate and efficient management of resources flows and supply chain, namely circularity. The three projects investigated in this paper, namely "*Opportunità*", "REPAiR" and "Urban_WINS", have been tackling different methodological and operative perspectives on circularity. Through this work, four key principles - which have been unrevealed - appear to be relevant in order to go towards a widespread application of circularity in the urban context. Thus, we discuss and interpret them as key principles to be faced to achieve circularity in cities, towards sustainability and resilience. These are: (i) closing the loops of resource flows; (ii) regenerating wastescapes; (iii) accounting of resource flows; and (iv) direct involvement of stakeholders in the management of resources.

The first key principle, (i) closing the loops of resource flows, is the main objective of "*Opportunità*", in which understanding the possible resource flows, imagining the possible finale use of resources, and disseminating best-practices of eco-innovation are all steps to closing the loop. Moreover, the project, to achieve and promote this objective, works to

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create innovative stakeholders networks, which was able to bring together sectors that traditionally do not work in the same supply chain, but that - under UM and CE - were able to find new links and chances to implement sustainable developments.
The second key principle, (ii) regenerating wastescapes, is the one developed by the project "REPAiR". In this project, abandoned and unutilised land is considered as a territorial resource, which need to be preserved and revalorised, and eventually re-inputted in the UM processes. Thus, Eco-Innovative Solutions and Strategies, to regenerate wastescapes, were developed in co-creation settings, inserted and tested in the GDSE tool. These solutions and strategies move from an 'end-of-pipe' approach towards a more circular use of the resources, being context-based, and having positive impacts on the environment.
The third key principle addressed principally by "Uban_WINS" is the (iii) accounting of resource flows. In "Urban_WINS" the Material Flows Accounting (MFA) was a pillar of the project development, the starting point for discussions and decisions. Moreover, these analytical results have been used in the methodological framework for UM, to design a UM toolkit, and mainly to co-create action plans for waste prevention and resource management in each pilot city. However, since this principle could be considered as a precondition to applying circularity, also "*Opportunità*" and "REPAiR" have been working towards understanding the flows of material resources. In both projects, the first step was to identify and map the quality and quantity of the resource flows involved in a specific supply chain (e.g. in "*Opportunità*") and in the wastescapes (e.g. in "REPAiR").
The knowledge of resource flows is necessary to ensure an effective resource utilization, to start a transition process towards a CE, and to reach, at a global scale, environmental sustainability (Desing *et al.*, 2020). This means that having a good knowledge of material and spatial resources is very important to all territorial realities to start the shift towards circularity. That knowledge allows us to understand the resources under pressure, the more relevant sectors, and where resources flow has more impacts, thus developing and creating effective eco-innovations and circularity.
The fourth key principle (iv) direct involvement of stakeholders in the management of resources was considered by all three projects to develop and implement concrete actions towards circularity. This issue builds upon the theories about Urban Living Labs, developed in literature so far. Living Labs are included in the participatory planning classification; in fact, "a collaborative real-life environment that engages various types of participants is a key requirement of living labs" (Hossain *et al.*, 2019). The research demonstrated that, through the application of the Living Lab methodology, it is possible to meet the different multidisciplinary perspectives which characterize the nature of urban studies; moreover Living Labs allow to effectively reach more effect more quickly, to share knowledge, data and information among different areas of expertise (Steen and Bueren, 2017). More specifically, in "*Opportunità*", a network of actors belonging to the agriculture and food sector was established to implement a better understanding, dissemination, and operationalization of the CE and UM approaches. In the H2020 projects "REPAiR" and "Urban_WINS" a large number of European stakeholders have been included since the beginning of the project process. In "REPAiR", stakeholders participate in co-creation processes held in the Peri-Urban Living Labs (PULLs), which are physical and virtual environments where experimenting with eco-innovations, implemented in peri-urban areas. In "Urban_WINS", stakeholders' involvement was applied in Urban *Agoràs*, which are one type of Living Labs, where to manage urban resources' flows and where to co-design urban

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action plans. Stakeholders' involvement turns out as a necessary precondition to make UM and CE approaches operative. The wide number of the relevant stakeholders involved in the projects has permitted to identify sectors and governance levels where UM and CE could be more sensitive. Moreover, they proposed and co-created tailored eco-innovative actions/solutions and long term strategies, and they identified new possible actors to be involved in establishing a broader value chain. "A higher interconnectivity between sectors – synergies that result in less waste and higher efficiency – is desirable. This can be achieved if the different sectors adopt a circular perception, together with transparency and cooperation" (de Ferreira and Fuso-Nerini, 2019).

Finally, it is important to underline that the three projects implement and test (eco)innovations. These are defined as follows: "Eco-Innovation refers to all forms of innovation – technological and non-technological – that create business opportunities and benefit the environment by preventing or reducing the environmental impact, or by optimizing the use of resources" (European Commission, 2011). Eco-innovations have the characteristics to be co-created by stakeholders and experts, with the objective to introduce circularity in one or more flows, through a local-based framework. Also this third issue builds upon the theory of Urban Living Labs whose aim is mainly to create innovative solutions for the urban sphere by working in a real-life context (Steen and Bueren, 2017). Moreover, eco-innovations can operate both to change the methodology, both to direct the implemented process; furthermore, eco-innovations are specific for the context investigated, and they can also change the contents or the technical aspects of the proposed solutions. Eco-innovations that have been introduced by the projects involve academics and non-academics, aiming to raise the ownerships of the solutions and start "constructive discussions about contested goals and norms" (John *et al.*, 2019). Moreover, they also aim to modify the processes related to the resource management sector, and the behaviours connected to waste management. It is important to consider behaviour and support at both the individual and organizational levels (González-Sánchez *et al.*, 2020; Dong *et al.*, 2019). On the one hand, the three projects have been implementing an innovative approach from a non-technological point of view, since they build networks of stakeholders, which share the same objectives towards circularity (e.g., *Agorà* and PULLs). They create business opportunities by suggesting actions that aim to shift from a linear approach towards closed loops of resource uses. On the other hand, they have been implementing technological innovations since they construct collaborative platforms to develop and test solutions (as in the case of the GDSE developed by REPAiR).

Nevertheless, the paper presents relevant issues for the application of the UM and CE approach in an urban environment, there are also some limits. This paper, not being a review of UM and CE approaches, obviously does not examine all the existing projects about these topics, but it focuses only on three of them, which have been implemented in Italy in the last four years by the authors. In this way, the perspective which has been highlighted so far about circularity - as interrelation about the principles of CE and UM – does not have the objective or the loan to be comprehensive and conclusive. It is just a first attempt to understand the principles and operative aspects of circularity in the urban environment. That emphasised the necessity for the decision-makers, urbanists, and designers, which approach to circularity, considering as many aspects as possible to reach a sustainable and circular city. The systemic dimension of circularity, which has been elucidated along with this paper, could only be achieved if all the features of circularity are

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tackled simultaneously, without neglecting any of them, to achieve sustainability and resilience. Thus, to overcome these limitations, it seems very valid that all the different initiatives which are taking place in Europe about circularity could be widely shared, and their key principles spread among the interested parties and well accessible.
The importance of maintaining alive a Europe-wide network of stakeholders, which could (a) share the aims and the achievements of their projects continuously, (b) learn from each other, and (c) have dissemination purposes. To support this intent, the European Union developed an important platform called ECESP (European Platform for the Circular Economy), that at the Italian level is called the "Italian Circular Economy Stakeholder Platform" (ICESP) [12]. These two mirroring platforms share the various initiatives and best practices taking place in Europe and Italy about the circular economy. The Italian platform aims to show, towards Europe, "the Italian way for circular economy" in a coherent way, to suggest and inspire new initiatives. Indeed, the ICESP platform interests all the major Italian stakeholders who are continuously engaged in working towards a more CE, by involving them in initiatives like annual national meetings and Working groups which cover the different aspects of circularity (e.g., research and eco-innovation, policy and governance, city and territory, best practices, and so on). Thus, analysing the practices showed will be possible to find other key principles and relevant operational aspects. Moreover, this platform sharing best practices and creating a huge network is the right place where discuss and define issues about the Circular Economy National Strategy.

6. Conclusions

Throughout this paper we have seen that, to achieve a high level of circularity at the city and territorial levels, but also at the corporative level, which could be sustainable over time, the collaboration of a strong network of stakeholders is needed at different stages of the projects' process. This requires the involvement and coordination of the different actors of the administrations of cities and regions (e.g., municipalities, regional authorities, etc.) and of the representatives of the resources supply chain (i.e., farmers, manufacturers, logistics services, facility operators, retailers), including also students and, more generally, citizens.
In recent years, UM and CE have attracted great attention - which is evident in the significant increase in the publication of articles both in scientific and in grey literature.
This paper, through the selection of three EU-funded projects identifies, and highlights four key issues to introduce, deeply understand and implement circularity into cities and territories, and to achieve sustainability, through an ameliorated UM. This with the aim to fill the gaps identified through the research questions. Specifically, the key issues addressed by the selected projects to achieve circularity are related to:
(i) closing the loops of resource flows;
(ii) regenerating wastescapes;
(iii) accounting of resource flows;
(iv) direct involvement of stakeholders in the management of resources.
Having implemented innovative methodologies and (virtual and physical) places for the engagement of all the stakeholders, these three EU-funded projects present a good knowledge of the resources flows, implementation of EIS, and a selection of best practices

[12] For further info see also the ICESP website: https://www.icesp.it/

for co-creation and sharing, which represent all fundamental aspects for circularity and sustainability. However, more research and projects are still needed towards the achievement of this objective and to study the deeper implications and interrelations among resource flows, urbanizations structures, and stakeholders' behaviours. The field of research in relation to circulatory which requires further studies could be summarized as follows: the deepening of the conceptualization, and the operationalization of recycling as a new material for urbanism. This constitute a new approach to be additionally integrated in the contemporary urban projects, which could involve material and immaterial resources.

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Attributions

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References

Agudelo-Vera, C. M., Mels, A. R., Keesman K. J., Rijnaarts, H. H. M. (2011), "Resource management as a key factor for sustainable urban planning". *Journal of Environmental Management*, vol. 92, pp. 2295-2303.

Amenta, L. (2019), *Beyond WASTESCAPES Opportunities for Sustainable Urban and Territorial Regeneration*. Delft University of Technology (TUDelft), Delft, The Netherlands.

Amenta, L. van Timmeren A. (2018), "Beyond Wastescapes: Towards Circular Landscapes. Addressing the Spatial Dimension of Circularity through the Regeneration of Wastescapes", *Sustainability*, Vol. 10, n. 12, pp. 4740.

Amenta, L., Attademo, A. (2016). Circular wastescapes. Waste as a resource for periurban landscapes planning. CRIOS, Vol. 12, n. 12, pp. 79–88.

Amenta, L., Qu, L. (2020), "Experimenting with Circularity When Designing Contemporary Regions: Adaptation Strategies for More Resilient and Regenerative Metropolitan Areas of Amsterdam and Naples Developed in University Studio Settings", *Sustainability*, Vol. 12, n. 11, pp. 4549.

Amenta, L., van Timmeren, A. (2018), "Beyond Wastescapes: Towards Circular Landscapes. Addressing the Spatial Dimension of Circularity through the Regeneration of Wastescapes", *Sustainability*, Vol. 10, n. 12, pp. 4740.

Amenta, L., Attademo A., Remøy H., Berruti G., Cerreta M., Formato E., Palestino M. F., Russo M. (2019), "Managing the Transition towards Circular Metabolism: Living Labs as a Co-Creation Approach." *Urban Planning*, Vol. 4, n. 3, pp. 5–18.

Andersen M. S. (2007), "An introductory note on the environmental economics of the circular economy". *Sustainability science*, Vol. 2, pp. 133–140.

Annunziata, A., Agovino, M., Ferraro, A., Mariani, A. (2020), "Household Food Waste: A Case Study in Southern Italy", *Sustainability*, vol. 12, n. 1495.

Arciniegas, G., Šileryté, R., Dąbrowski, M., Wandl, A., Dukai, B., Bohnet, M., Gutsche, J.-M. (2019), "A Geodesign Decision Support Environment for Integrating Management of Resource Flows in Spatial Planning", *Urban Planning*, Vol. 4, n.3, pp. 32.

ARUP (2016), *The Circular economy and the Built Environment*. London, UK.

Beatrice J., Luederitz C., Lang D.J., von Wehrden H. (2019), "Toward Sustainable Urban Metabolisms. From System Understanding to System Transformation", *Ecological Economics*, Vol. 157, pp. 402–14.

Berger, A. (2006a), *Drosscape: Wasting Land in Urban America*. Princenton, New York.

Berger, A. (2006b), "Drosscape", in *The Landscape Urbanism Reader*, New York: Princenton Architectural Press, pp. 198-217.

Brenner, N. (ed.) (2014), *Implosions/explosions: Towards a study of planetary urbanization*. Jovis, Berlin.

Cognetti, F. (2019), "Il Ritorno Ai Luoghi Passando Dai Flussi. Confini, Mobilità e Tempi Al Centro Di Una Nuova Agenda Di Politiche", in: *Per Una Città Sostenibile*, Donzelli Editore, Roma, pp. 63–72.

Cui, X. (2018), "How can cities support sustainability: A bibliometric analysis of urban metabolism", *Ecological Indicator*, Vol. 18, n. 93, pp. 704–717.

Dąbrowski, M., Varjú V., Amenta L. (2019), "Transferring Circular Economy Solutions across Differentiated Territories: Understanding and Overcoming the Barriers for Knowledge Transfer", *Urban Planning*, Vol. 4, n. 3, pp. 52–62.

de Leo, D., Palestino, M. F. (2017), "S-regulation matters", in Balducci, A., Fedeli, V., Curci F. (eds.), *Post-metropolitan territories. Looking for a new urbanity*, Routledge, New York, pp. 274–280.

De Marchi, G., Lucertini, G., Tsoukiàs, A. (2016), "From evidence-based policy making to policy analytics", *Annals of Operations Research*, Vol. 236, n. 1, pp. 15–38.

De Martino, P. (2016), "Land in Limbo: Understanding planning agencies and spatial development at the interface of the port and city of Naples", in Hein, C. (ed.), *History Urbanism Resilience: Planning and Heritage*, Proceedings of the 17th International Planning History Society Conference, pp. 203–216.

Design, H., Brunner, D., Takacs, F., Nahrath, S., Frankenberger, K. Hirschier, R. (2020), "A Circular Economy within the planetary boundaries: towards a resource-

based, systemic approach", *Resources, Conservation and Recycling*, vol. 155, n. 104673.

Dong, C., Li, Q., Shen, B., Tong, X. (2019), "Sustainability in Supply Chains with Behavioral Concerns", *Sustainability*, Vol. 11, n. 4051.

EEA (2011), *Resource efficiency and waste*. European Environment Agency, Copenhagen.

EEA (2016), *More from less - material resource efficiency in Europe.* European Environment Agency, Copenhagen.

EEA (2016), Circular economy in Europe. Developing the knowledge base (Vol. No. 2). European Environment Agency.

EEA (2019), *Resource efficiency and the circular economy in Europe 2019 – even more from less.* European Environment Agency, Copenhagen.

Ellen MacArthur Foundation (2017), *What Is The Circular Economy?* EMF report.

Ellen MacArthur Foundation, and Arup (2019), *Circular Economy in Cities: Project Guide.* EMF report.

European Commission (2008), DIRECTIVE 2008/98/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 November 2008 on Waste and Repealing Certain Directives.

European Commission (2011), Innovation for a sustainable Future - The Eco-innovation Action Plan (Eco-AP).

European Commission (2014), Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions; *Towards a circular economy: A zero waste programme for Europe*, COM/2014/0398 final/2.

European Commission (2014). Towards a circular economy: A zero waste programme for Europe. European Commission.

European Commission (2015), Communication from The Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee of The Regions; *Closing the loop - An EU action plan for the Circular Economy* COM/2015/0614 final.

European Commission (2016a), Grant Agreement n. NUMBER — 688920, 'REPAiR: REsource Management in Peri-Urban AReas: Going Beyond Urban Metabolism'. EU Commission Participant portal.

European Commission (2016b), Grant Agreement n. NUMBER — 690047, 'Urban_WINS - Urban metabolism accounts for building Waste Management Innovative Networks and Strategies'. EU Commission Participant portal.

European Commission (2020), Communication from The Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee Of The Regions; *A new Circular Economy Action Plan For a cleaner and more competitive Europe*, COM/2020/98 final.

Ferrão, P., Fernández, J. E. (2013), *Sustainable urban metabolism*. MIT press.

de Ferreira, A. C., Fuso-Nerini F. (2019), "A Framework for Implementing and Tracking Circular Economy in Cities: The Case of Porto." *Sustainability*, Vol. 11, n. 1813.

Geemente Rotterdam, IABR, FABRIC, JCFO, TNO (2014), *Urban Metabolism Sustainable development of Rotterdam*. Rotterdam.

.

Geissdoerfer, M., Savaget, P., Bocken, N. M. P., Hultink, E. J. (2016), "The Circular Economy e A new sustainability paradigm?", *Journal of Cleaner Production*, Vol. 143, pp. 757-768.

Ghisellini, P., Cialani C., Ulgiati S. (2014), "Circular economy: State-of-the-art, promises and expectations. A review", in *Working Papers in Transport, Tourism, Information Technology and Microdata Analysis.* Dalarna University, Falun, Sweden.

González-Sánchez, R., Settembre-Blundo, D., Ferrari, A. M., García-Muiña, F. E. (2020), "Main Dimensions in the Building of the Circular Supply Chain: A Literature Review", *Sustainability*, Vol. 12, n. 2459.

Hoekman, P., von Blottnitz, H. (2017), "Cape Town's metabolism: Insights from a material flow analysis", *Journal of Industrial Ecology*, Vol. 21, pp. 1237–1249.

ISPRA (2019), *Rapporto Rifiuti Urbani, Edizione 2019*. ISPRA report.

Kalmycova, Y., Sadagopan, M., Rosado, L. (2018), "Circular economy – From review of theories and practices to development of implementation tools", *Resources, Conservation & Recycling*, Vol. 135, pp. 190–201.

Kennedy, C., Pincetl, S., Bunje, P. (2011), "The study of urban metabolism and its applications to urban planning and design", *Environmental Pollution*, Vol. 159, pp. 1965–1973.

Kennedy, C.A., Cuddihy, J., Engel Yan, J., (2007), "The changing metabolism of cities". *Journal of Industrial Ecology*, Vol, 11, pp. 43–59.

Kirchherr, J., Reike, D., Hekkert, M. (2017), "Conceptualizing the Circular Economy: An Analysis of 114 Definitions", *Resources, Conservation and Recycling*, Vol. 127, pp. 221–32.

Korhonen, J., Honkasalo, A., Seppälä, J. (2018), "Circular Economy: The Concept and its Limitations", *Ecologicgal Economics*, Vol. 143, pp. 37-46.

Krausman, F., Schandl, H., Eisenmenger, N., Gijium, S., Jackson, T. (2017), "Material Flow Accounting: Measuring Global Material Use for Sustainable Development", *Annual Review of Environment and Resources*, Vol. 42, pp. 647–75.

Lieder, M., Rashid, A. (2016), "Towards circular economy implementation: a comprehensive review in context of manufacturing industry", *Journal of Cleaner Production*, Vol. 115, pp. 36-51.

Linger, P., Müssig, J., Fischer, H., Kobert, J. (2002), "Industrial Hemp (Cannabis Sativa L.) Growing on Heavy Metal Contaminated Soil: Fibre Quality and Phytoremediation Potential", *Industrial Crops and Products*, Vol. 16, n. 1, pp. 33–42.

Longato, D., Lucertini, G., Dalla Fontana, M., Musco, F. (2019), Including Urban Metabolism Principles in Decision-Making: A Methodology for Planning Waste and Resource Management", *Sustainability*, Vol. 11, n. 7, pp. 2101.

Lucertini, G. Musco, F. (2020), "Circular Urban Metabolism Framework", *One Earth*, Vol. 2.

Marin, J., de Meulder, B. (2018), "Urban landscape design exercises in urban metabolism: Reconnecting with Central Limburg's regenerative resource landscape", *Journal of Landscape Architecture*, Vol. 13, pp. 36–49.

Milios L. (2018), "Advancing to a Circular Economy: three essential ingredients for a comprehensive policy mix", *Sustainability Science*, Vol. 13, pp. 861–878.

Mokter, H., Leminen S., Westerlund M., (2019), "A Systematic Review of Living Lab Literature", *Journal of Cleaner Production*, Vol. 213, pp. 976–88.

.

Moreau, V., Sahakian, M., van Griethuysen, P., Vuille, F. (2017), "Coming Full Circle: Why Social and Institutional Dimensions Matter for the Circular Economy", *Journal of Industrial Ecology*, Vol. 21, n. 3, pp. 497-506.

Morseletto, P. (2020), "Targets for a Circular Economy", *Resources, Conservation and Recycling*, Vol. 153, n. 104553.

Murray, A., Skene, K., Haynes, K. (2015). "The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context", *Journal of Business Ethics*, Vol. 140, pp. 369-380.

Newman, P. W. G. (1999), "Sustainability and cities: extending the metabolism model", *Landscape and Urban Planning*, Vol. 44, pp. 219-226.

O'Shea, C., Hegeman, L., Bennett, C. (2016), "Logistical ecologies of the North American operational land-scape", *MAS Context*, Vol. 28, pp. 8–35.

Pincetl, S., Bunje, P., Holmes, T. (2012), "An expanded urban metabolism method: Toward a systems approach for assessing urban energy processes and causes", *Landscape and Urban Planning*, Vol. 107, pp. 193–202.

Potting, J. (2017), *Circular Economy: Measuring Innovation in the Product Chain*.

Rapoport, E. (2011), *Interdisciplinary Perspectives on Urban Metabolism. A Review of the Literature*, UCL Environmental Institute Working Paper, Development Planning Unit.

Regione Veneto (2014), *POR Veneto FESR*, https://www.regione.veneto.it/web/programmi-comunitari/documenti-di-programmazione1#Programma_Operativo_Regionale_FESR_2014-2020

Remøy, H., Wandl, A., Ceric, D., Van Timmeren, A. (2019), "Facilitating Circular Economy in Urban Planning", *Urban Planning*, Vol. 4, n. 3, pp. 1.

REPAiR (2017), *PULLs Handbook REPAiR*, Deliverable 5.1 EU Commission Participant Portal.

REPAiR (2018a), *Process Model for the Two Pilot Cases: Amsterdam, the Netherlands & Naples, Italy*, Deliverable 3.3 EU Commission Participant Portal.

REPAiR (2018b), *Handbook: How to Run a PULL*, Deliverable 5.4. EU Commission Participant portal.

REPAiR (2018c), *Eco-Innovative Solutions Naples*. Deliverable 5.3 EU Commission Participant portal.

Rosado, L., Niza, S., Ferrão, P. (2014), "A Material Flow Accounting Case Study of the Lisbon Metropolitan Area using the Urban Metabolism Analyst Model", *Journal of Industrial Ecology*, Vol, 18, pp. 84–101.

Russo, M., Amenta, L., Attademo, A., Cerreta, M., Formato, E., Garzilli, F., Mazzarella Scocca, C., Rigillo, M., Vittiglio, V. (2019), "Short Supply Chain of Waste Flows for Landscape Regeneration in Peri- Urban Areas", in *Sardinia Symposium 2019 Proceedings / 17th International Waste Management and Landfill Symposium* / 30 September – 04 October 2019. CISA Publisher, Padova, Italy.

Sahely, H. R., Dudding, S., Kennedy, C. A. (2003), "Estimating the urban metabolism of Canadian cities: Greater Toronto Area case study", *Canadian Journal of Civil Engineering*, Vol. 30, pp. 468–483.

Schröder, P., Lemille, A., Desmond, P. (2020), "Making the circular economy work for human development", *Resources, Conservation and Recycling*, Vol. 156, n. 104686.

Silva, A., Augusto, B., Rafael, S., Reis, J., Lopes, M., Costa, S., Borrego, C. (2020), "Modelling of Regional Economic Metabolism", *Climate*, Vol. 8, pp. 52.

.

Simpson, G. B., Jewitt, G. P. W. (2019), "The Development of the Water-Energy-Food Nexus as a Framework for Achieving Resource Security: A Review", *Frontiers in Environmental Science*, Vol. 7, n. 8.

Smoll, M., Kulczycka, J., Avdiushchenko, A. (2017), "Circular economy indicators in relation to eco-innovation in European regions", *Clean Technologies and Environmental Policy*, Vol. 19, pp. 669–678.

Steen, K., van Bueren, E. (2017), *Urban Living Labs. A Living Lab Way of Working*, Amsterdam Institute for Advanced Metropolitan Solutions, Delft University of Technology.

Thomas, E., Almenar, J. B., Niza, S., Proença, V., Rugani, B. (2019), "Pathways to Modelling Ecosystem Services within an Urban Metabolism Framework", *Sustainability*, Vol. 11, n. 2766.

Thomson, G., Newman, P. (2018), "Urban fabrics and urban metabolism–from sustainable to regenerative cities", *Resource, Conservation and Recycling*, Vol. 132, pp. 218–229.

van Timmeren, A. (2014), *The Concept of the Urban Metabolism (UM)*, Delft University of Technology, Faculty of Architecture, Department of Urbanism, Chair Environmental Technology & Design.

Tsoukiàs, A. (2007), "On the concept of decision aiding process: an operational perspective", *Annals of Operations Research*, Vol. 154, pp. 3–27.

Vanham, D., Leip, A., Galli, A., Kastner, T., Bruckner, M., Uwizeye, A., van Dijk, K., (2019), "Environmental Footprint Family to Address Local to Planetary Sustainability and Deliver on the SDGs", *Science of The Total Environment*, Vol. 693, n. 133642.

Vasconcelos, L. M. T, Silva, F. N. Z., Ferreira, F. M. G., Ferreira, J. C. R., Martinho, M. G. M. (2017), "Urban_WINS: Construção de redes participativas para a gestão de residuos", *REDE – Revista Eletrônica do PRODEMA*, Vol. 11, n. 2, pp. 50-61.

Velenturf, A. P. M., Archer, S. A., Gomes, H. I., Christgen, B., Lag-Brotons, A. J., Purnell, P. (2019), "Circular economy and the matter of integrated resources", *Science of The Total Environment*, Vol. 689, pp. 963-969.

Voskamp, I. M., Stremke, S., Spiller, M., Perrotti, D., van der Hoek, J. P., Rijnaarts, H. H. (2017), "Enhanced performance of the Eurostat method for comprehensive assessment of urban metabolism: A material flow analysis of Amsterdam", *Journal of Industrial Ecology*, Vol, 21, pp. 887–902.

Wang, Y., Chen, P. C., Ma, H. W., Cheng, K. L., Chang, C. Y. (2018), "Socio-economic metabolism of urban construction materials: A case study of the Taipei metropolitan area", *Resource, Conservation and Recycling*, Vol. 128, pp. 563–571.

Witjesa, S., Lozanoa, R. (2016), "Towards a more Circular Economy: Proposing a framework linking sustainable public procurement and sustainable business models", *Resources, Conservation and Recycling*, Vol. 112, pp. 37–44.

Yigitcanlar, T., Dizdaroglu, D. (2015), "Ecological approaches in planning for sustainable cities.A review of the literature", *Global Journal of Environmental Science and Management*, Vol. 1, n. 2, pp. 159-188.

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