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Approaches and Tools for Implementing the Circular City Model

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CIRCULAR CITY MODEL AND ITS IMPLEMENTATION: TOWARDS AN INTEGRATED EVALUATION TOOL

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Abstract

As the world continues to urbanize, sustainable development challenges will be more and more concentrated in cities and they increasingly require identifying and implementing new development models and strategies. The circular economy model can be implemented in the cities in order to achieve sustainable development. Although some cities are moving towards this direction, there is still ambiguity around this concept.
Circular cities are a new phenomenon and, to date, it is very difficult to build empirical evidence of their success (or failure). This paper aims to analyse the circular city model starting from definitions in literature and six case studies of European circular metropolitan cities. In particular, this paper is focused on the evaluation framework for assessing and monitoring the efficiency of the circular cities, that is to assess (positive and/or negative) impacts of projects and initiatives of the circular city agendas.

Keywords: circular city, metropolitan city, integrated evaluation

Il MODELLO DI CITTÀ CIRCOLARE E LA SUA ATTUAZIONE: VERSO UNO STRUMENTO DI VALUTAZIONE INTEGRATO

Sommario

Poichè il mondo risulta sempre più urbanizzato, le sfide dello sviluppo sostenibile saranno sempre più concentrate nelle città, richiedendo l'identificazione e l'attuazione di nuovi modelli e strategie di sviluppo. Il modello di economia circolare può essere implementato nelle città per il raggiungimento dello sviluppo sostenibile. Sebbene alcune città si stiano già muovendo verso questa direzione, c'è ancora ambiguità attorno a questo concetto.
Le città circolari sono un fenomeno nuovo e, ad oggi, è molto difficile costruire evidenza empirica del loro successo (o fallimento). Il presente paper si propone di analizzare il modello della città circolare partendo dalle definizioni in letteratura e da sei casi di studio di città europee metropolitane circolari. In particolare, l'attenzione è posta sugli strumenti per valutare e monitorare l'efficienza delle città circolari, ovvero valutare gli impatti (positivi e/o negativi) di progetti e iniziative dell'agenda delle città circolari.

Parole chiave: città circolare, città metropolitana, valutazione integrata

1. Introduction: metropolitan city and circular economy

We live in a world of growing cities and the definition of a metropolitan city can differ throughout countries. A general definition that we can assume is that a metropolitan area is an economic region comprising one or more cities and their surrounding areas, all linked by economic and commuting ties (Trujillo and Parilla 2016).

Some definitions are referred also to the number of inhabitants living in them. In the United States, metro areas are defined by the U.S. Office of Management and Budget (OMB) to include one or more urbanized areas of at least 50,000 inhabitants, plus outlying areas connected by commuting flows (Office of Management and Budget, 2013).

The European Observation Network for Territorial Development and Cohesion (ESPON) defines metro areas as having one or more functional urban areas of more than 500,000 inhabitants (ESPON, 2007).

According to the OECD classification of functional urban areas in reference to population size (small urban areas, Medium-sized urban areas, Metropolitan areas, Large metropolitan areas), metropolitan areas are that characterized by a population between 500,000 and 1.5 million (OECD, 2013).

Cities are home to a growing percentage of the world's population. According to Eurostat (www.ec.europa.eu), 72% of the European population currently lives in cities and metropolitan areas and it is foreseen that, by the year 2050, this percentage will reach 80%. As the world continues to urbanize, sustainable development challenges will be more and more concentrated in cities and they increasingly require identifying and implementing new models and development strategies.

Current economic and urbanization trends place significant pressure on urban resources, systems and infrastructures, and demand for new approaches in governing, financing and monitoring urban performances. The metropolitan cities are facing many challenges related to the overall increase in costs.

The circular economy offers a perspective to reduce this costs coming from the transformation of the agglomeration economies into agglomeration dis-economies and to operationalize sustainable development principles.

This paper aims to analyse the circular city model. After an overview of the circular economy concept (§2), this paper investigates how this model can be implemented in the cities in order to achieve sustainable development. To this end, the definitions of "circular city", both from academic research and from reports of cities that are concretely implementing this model, are examined (§3). Then the European metropolitan cities that are defining themselves as circular cities are critically investigated and compared (§§ 4-5-6). The attention is then focused on the evaluation framework for supporting decision making processes in the circular city strategies (§7-8-9).

2. The circular economy model

The current economy can be largely considered as linear: virgin materials are taken from nature and used to produce goods, which are then consumed and eventually disposed of. In a world characterized by finite resources (as also COP21 and COP22 highlighted), this model cannot work in the long run, and there are evidences that it is reaching its limits.

We need to move towards a more virtuous economic model and, at the moment, we are only at the beginning of this way.

The circular economy model, based on the principle that in nature nothing is "waste" and

everything can become a "resource", is proposed to operationalize sustainable development principles. The circular economy can be defined as "restructuring the industrial systems to support ecosystems through the adoption of methods to maximize the efficient use of resources by recycling and minimizing emissions and waste" (Preston, 2012). It is referred to how resources' flows can be closed (Chertow, 2000).

Through circular economy processes, inputs are minimized and, at the same time, outputs are maximized, preserving as long as possible the value of the resources (Preston, 2012).

In this model the value of products, materials and resources is maintained in the economy for as long as possible and waste are minimised.

To date, 114 definitions of circular economy exist in literature (Kirchherr et *al*., 2017). The circular economy concept originates in ecological and environmental economics and industrial ecology. It can be brought back to Kenneth Boulding's work that deals with the limited natural resources available for human activities and Georgescu-Roegen's work on "thermodynamics in economic systems dictating matter and energy degradation from 1971" (Georgescu-Roegen, 1971; 1976).

United Nations have introduced in the paragraphs 71-74 of the New Urban Agenda, the outcome document of Habitat III conference (October 2016), the notion of circular economy as a general development model that produces impacts on natural and social contexts, while generating new economic wealth. This stimulates an indefinite enlargement of the lifetime of resources and their use values and promotes circuits of cooperation among different actors.

The United Nations Environment Programme (UNEP) in 2016 has recognized the necessity to entrench the principles of the circular economy in order to move towards sustainable development. Circular economy represents "a tangible set of solutions for reaching sustainable patterns of production and consumption". It affects economy, jobs and the environmental system.

The European Commission has adopted a package to support the EU's transition to the circular economy, including legislative proposals aimed at stimulating the European route towards circular economy (European Commission, 2015). It is an essential contribution to the EU's efforts to develop a "sustainable, low carbon, resource efficient and competitive economy". The objective of this package is to boost economic growth, making it more sustainable and competitive in the long term. It considers circular economy as a means for contributing to innovation, growth and job creation (European Commission, 2015).

According to Ellen MacArthur Foundation definition, the circular economy, that provides multiple value-creation mechanisms, is based on three principles (Ellen MacArthur Foundation, 2015): preservation and enhancement of natural capital, optimization of resources by circulating products, components, and materials, fostering system effectiveness by revealing and designing out negative externalities.

The Ellen MacArthur Foundation identifies six business actions to support the above-mentioned three principles: Regenerate, Share, Optimize, Loop, Virtualize, Exchange (Ellen MacArthur Foundation, 2015).

In the general interpretation, circular economy is mainly referred to waste cycle management. But this approach should be overcome and transferred from a sectorial approach (waste management) to the comprehensive city organization, its economy, its social system, its governance (Fusco Girard *et al.*, 2014 VIETRBO; Angrisano *et al.* 2016; Fusco Girard, 2012; Ravetz *et al*., 2012) in order to improve urban productivity.

Therefore, the concept of circularization processes can be applied not only to material and natural flows (zero-waste approach), but also to wider issues, as economic patterns of investment/re-investment, or political systems of participative multi-level partnership governance or too knowledge (Angrisano *et al.*, 2016).
The circular economy can be recognized as a general development model, able to turn the linear urban metabolism into a new urban circular metabolism, in which input and output flows are "closed".

3. What is a circular city?

The circular economy offers a great opportunity to increase urban productivity and at date there are some good practices of circularization of processes at different scales (industrial symbiosis, etc.) in which some benefits from the implementation of circular processes are achieved: reduction of materials and energy costs, reduction of carbon emissions, etc. (Fujita *et al.* 2013).
The concept of circular economy can be implemented in the cities in order to achieve a sustainable development.
Why can we adopt the circular approach at city level? As also Croci (2018) highlights, there are different reasons. First of all, because materials and nutrients are here concentrated; so, they are the perfect place for reducing waste with a "closed loop" thinking (proximity of people and materials in the urban environment, exchange of resource from the city's hinterland).
Furthermore, cities are focal point for materials flows, but also for productivity and innovation. The scale is good for activating synergies among entrepreneurs, consumers and local authorities and providing innovative services and business models. Additionally, city governments often have relevant powers over spatial planning, solid waste management and building standards (although their institutional, technical and financial capacity to address these varies greatly) (Croci, 2018).
Today there are many cities that are defining themselves as "circular city". But what is a circular city? Here below a list of definitions about circular city, both by academic research and by other bodies (Tab. 1) and reports of cities that are concretely implemented this model.

Tab. 1 – Definitions of circular city from literature

Definitions of circular city (literature)	
Source	**Definition**
Ellen MacArthur Foundation (Ellen MacArthur Foundation, 2015)	A circular city embeds the principles of a circular economy across all its functions, establishing an urban system that is regenerative, accessible and abundant by design. These cities aim to eliminate the concept of waste, keep assets at their highest value at all times, and are enabled by digital technology. A circular city seeks to generate prosperity, increase liveability, and improve resilience for the city and its citizens, while aiming to decouple the creation of value from the consumption of finite resources.

	A circular city will likely include the following elements: – A built environment that is designed in a modular and flexible manner, sourcing healthy materials that improve the life quality of the residents, and minimise virgin material use. It will be built using efficient construction techniques, and will be highly utilised thanks to shared, flexible and modular office spaces and housing. Components of buildings will be maintained and renewed when needed, while buildings will be used where possible to generate, rather than consume, power and food by facilitating closed loops of water, nutrients, materials, and energy, to mimic natural cycles. – Energy systems that are resilient, renewable, localised, distributed and allow effective energy use, reducing costs and having a positive impact on the environment. – An urban mobility system that is accessible, affordable, and effective. A multi-modal mobility structure that will incorporate public transportation, with on-demand cars as a flexible last-mile solution. Transportation will be electric-powered, shared, and automated. Air pollution and congestion will belong in the past, and excessive road infrastructure will be converted to serve other needs of citizens. Central to vehicle design will be remanufacturing, durability, efficiency and easy maintenance. – An urban bioeconomy where nutrients will be returned to the soil in an appropriate manner, while generating value and minimising food waste. Nutrients could be captured within the organic fraction of municipal solid waste and wastewater streams, and processed to be returned to the soil in forms such as organic fertiliser – used for both urban and rural agriculture. Through urban farming, the city will be able to supply some of its own food, reusing food waste and sewage in closed and local loops to produce vegetables, fruit, and fish. Such a system could also provide a more resilient, diversified and cost-effective energy system in the city through the generation of electricity from wastewater, biofuels and biorefineries. These will offer additional revenue streams to the city, capitalising on the utilisation of material and nutrients that are already in use. – Production systems that encourage the creation of 'local value loops'. This means more local production, and increased and more diverse exchanges of value in local economies. Maker-labs (to encourage local production, repair, and distributive manufacturing), collective resource banks (to even out the demand and supply of materials) and digital applications (to broker the exchange of goods, materials, and services) would feature in these local, circular production systems.
World Economic Forum (2018)	A circular city embeds the principles of a circular economy across all of its functions, establishing an urban system that is regenerative and restorative by design. In such a city, the idea of waste is eliminated, with

	assets kept at their highest levels of utility at all times and the use of digital technologies a vital process enabler. A circular city aims to generate prosperity and economic resilience for itself and its citizens, while decoupling value creation from the consumption of finite resources. Seven principles in the transition towards a circular economy can be identified starting from circular Amsterdam. These principles can be extended to define a vision and an action roadmap on circularity in cities: – Closed loop, all materials enter into an infinite cycle (technical or biological); – Reduced emissions, all energy comes from renewable sources; – Value generation, resources are used to generate (financial or other) value; – Modular design, modular and flexible design of products and production chains increases adaptability of systems; – Innovative business models, new business models for production, distribution and consumption enable the shift from possession of goods to (use of) services; – Region-oriented reverse logistics, logistics systems shift to a more region-oriented service with reverse-logistics capabilities; – Natural systems upgradation, human activities positively contribute to ecosystems, ecosystem services and the reconstruction of "natural capital". A circular city encourages the use of systems thinking to provide economic, social and environmental benefits for its citizens, while also looking to improve the quality of life.
www.argoit.com **www.forumpa.it**	Circular cities are sustainable and competitive cities that move from a linear economic model (in which life cycle of goods is "take-make-dispose") to an alternative model, whose key word is "reuse" (that is, a "circular economy"). In general, a circular city is a city that becomes rational in the use of energy, in the use of greenery and urban gardens. It is a city that valorizes all that can give quality to the environment, while promoting an increasingly qualified employment.
www.citiesintransition.eu	The Circular City is where we manage waste, commodities and energy in smarter and more efficient ways. What can we expect from a circular approach? Less pressure on our environment, new business models, innovative designs and new alliances and cooperation between different stakeholders.
www.ucl.ac.uk **www.circularcitieshub.com**	Circularity in resource flows in cities can tackle the consumption of resources, such as energy, water, buildings and land. Systems integration, flexibility, intelligence, cooperative behaviour, localisation, recycling and renewable resources are the key concepts under-pinning the Circular City. In a circular city: resources can be cycled between urban activities; resources can be cycled within city regions; cities can be designed so that land and infrastructure can be re-used/recycled over time.

Koenders and de Vries (2015)	The circular city is a metaphor for a new way of looking at the city and of organizing it. The idea is that linear processes in the circular city, from extraction to waste can be (partly) replaced by circular processes and that lasting connections can be made between flows. A circular society is less dependent on the import of scarce and precious resources and at the same time the negative effects of production and consumption will be limited.
Marin and De Meulder (2018)	It seems evident that a circular city should include more than the sum or multiplication of urban circular economies. They conceal transition drivers leading to varying circularity interpretations. However, even though circular city representations spatialize specific sustainability framings and the associated ideological positions, these framings generally remain unarticulated, creating confusion about the imaginaries' statuses. On one hand, certain images appear to be mere celebrations of technological progress, proposing generic solutions, such as green roofs and facades. On the other end of the spectrum, images not necessarily claiming to articulate circularity, integrate nature, culture, and society in place-specific circular configurations. Different ustainability framings exist for "circular cities" as well as potential drivers defining circularity.
Prendeville *et al.*, 2018	Cities are first-and-foremost places for people and their sustainable futures. In any conceptualization of a circular city these issues require consideration. According to EMF, the circular city is the city based on the following circular economy principles: Regenerate, Share, Optimize, Loop, Virtualize and Exchange. In addition, urban sustainability is about resilience and livability beyond the city's infrastructure and technology. In light of this, the concept a circular city can be seen as an element in the larger goal of developing a future-proof city. This means that a circular city is a city that practices CE principles to close resource loops, in partnership with the city's stakeholders (citizens, community, business and knowledge stakeholders), to realize its vision of a future-proof city.
Sukhdev *et al.*, 2018	A circular city embeds the principles of a circular economy across all its functions, establishing an urban system that is regenerative and restorative by design. These cities aim to eliminate the concept of waste, keep assets at their highest utility at all times, and are enabled by digital technology. A circular city aims to generate prosperity and economic resilience for the city and its citizens, while decoupling this value creation from the consumption of finite resources.

As emerges from the above definitions, the circular city embeds the principles of the circular economy, establishing an urban system that is regenerative and accessible. The closure of loops is a fundamental concept at the basis of such city: linear processes are turned into circular ones. The idea of eliminating (or minimizing) waste and the rational and efficient use of energy are highlighted in almost all definitions. The role of digital

technology to enable the circular city is also recognized.
Flexibility (as in built environment sector), cooperative behaviour, integration, recycling are key concepts of the circular city. The greenery and the urban gardens are also recognized as elements for enhancing the environment of the circular city. Innovative business models are necessary to implement this new urban model.
Many definitions refer to the description provided by the Ellen MacArthur Foundation. In addition to the aforementioned concepts, the Ellen MacArthur Foundation recognizes the circular city as a city in which, in particular, the built environment is designed in a modular and flexible manner; energy systems are resilient, renewable, localised reducing costs and having a positive impact on the environment; the urban mobility system is accessible, affordable and effective; the production systems encourage the creation of "local value loops"; nutrients will be returned to the soil in an appropriate manner according to an urban bioeconomy (Ellen MacArthur Foundation, 2015). The contribution to the quality of citizens' life is not highlighted (except in two definitions). So, in almost all definitions the human dimension of this model doesn't emerge.
In the analysed circular cities reports explicit definitions are lacking, but they can be deduced from these. In Table 2 these definitions deduced from reports.
The contribution of the circular city model to the improvement of quality of life for citizens is underlined several times in the reports of circular cities (contrary to the definitions in literature), in particular in reference to the production of new jobs and new businesses.
It is recognized the necessity to involve different "elements" (many stakeholders, many actors, many resources, many technologies, etc.) to implement this model.
The closure of loops, the use of energy coming from renewable sources, modular and flexible design are concepts emerging from definitions in reports for implementing the circular city model and make cities more competitive.
Although circular cities differ in size, geographic location, economy, etc., these definitions have some points in common. In the following paragraph the cities that are defining themselves as circular cities are compared.

Tab. 2 – Definitions of circular city from reports

Definitions of circular city (reports)	
Source	**Definition**
Circular Glasgow (Circle Economy; 2016b)	Circularity in cities: the circular economy is a radical solution that advocates a fundamental change in our current economic system, reducing the environmental burden on the planet. For cities, the circular economy is a way to improve the quality of life for citizens by creating jobs and spurring innovation, while reducing the resources needs. A circular economy makes business sense by using new and emerging technology to create opportunities for innovation and the development of new products and production techniques. Creating a circular city is a complex journey involving many organisations, companies, technologies and resources. Where do we start in order to make a city more circular? Glasgow is committed to growing a greener economy in its transformation into a

	more sustainable, smart and resilient city. A circular economy fits well within this ambition.
Circular Amsterdam (Circle Economy; 2016a)	The city of Amsterdam works according to the following seven principles of the circular economy: – all materials enter into an infinite technical or biological cycle. – all energy comes from renewable sources; – resources are used to generate (financial or other) value; – modular and flexible design of products and production chains increase adaptability of systems; – new business models for production, distribution and consumption enable the shift from possession of goods to (use of) services; – logistics systems shift to a more region oriented service with reverse-logistics capabilities; – human activities positively contribute to ecosystems, ecosystem services and the reconstruction of "natural capital". For citizens, a more circular city will improve their quality of life, create new jobs and form new business models for entrepreneurs.
Circular London (LWARB, 2017)	The current economy is linear, which means that things are made with virgin raw materials, used and then thrown away. In contrast, a circular economy keeps products and materials circulating within the economy at their highest value for as long as possible, through re-use, recycling, remanufacturing, delivering products as services and sharing. A circular economy approach is not only more resource efficient but also protects businesses from fluctuating commodity prices. It provides an opportunity to develop a more stable operating environment for manufacturers, retailers and consumers. Circular economy business models may be of particular benefit to London in the post-Brexit economic environment creating the possibility of new revenue streams, markets and product lines. This is LWARB's vision for London, a circular city which capitalises on these opportunities to become a more resilient, resource-efficient and competitive city of the future.
Circular Rotterdam (Gemeente Rotterdam, 2016)	Rotterdam is the European center for biobased and circular economy, more jobs, zero residual waste, lower costs and increased prosperity for its citizens. Towards 2030 Rotterdam will become resource resilient, it will build, produce, and consume more circularly. The port will be a global hub for (secondary) materials and a circular industrial cluster. This implicates that: – The circular economy will provide the citizens of Rotterdam with more jobs and job opportunities, a higher standard of living, lower costs, and a cleaner more prosperous Rotterdam. – All "Rotterdammers" will benefit from the circular economy and will have easy access to circular services and products. – Public procurement will be based on circular principles and inspire the private sector to adopt attractive circular economy business models.

	– The economic clusters, Food, Medical, Cleantech/Maritime, and Urban development/Construction will be the economic pillars in the circular economy of Rotterdam, with other clusters following in their footsteps. – Rotterdam will lead the way for new business models based on circular principles including circular product design.

4. How European metropolitan cities are concretely implementing the circular city model?

Cities are the place where circular economy can be concretely implemented. Indeed, circular cities exploration is in its initial phase and is rather complex. European metropolitan cities are implementing the circular city model in different way. Six metropolitan cities, that are defining themselves as circular city, have been analysed in this study: Amsterdam, Antwerp, Glasgow, London, Paris and London.

All of them are implementing strategies and actions to become "circular" and they have summarized their "journey" towards this new city model in reports (Circle Economy; 2016a; 2016b; LWARB, 2017; Gemeente Rotterdam, 2016; Mairie De Paris, 2017).

In order to move towards the implementation of the circular city model, all of the examined cities have, as first step, deeply analysed their status quo to understand what no circular is in the current economy and if it can be turn into circular organization. It needs to identify, first of all, which "areas/elements" (both in a physical sense and not) can be "used" to activate the circular processes.

In the Glasgow case study, in particular, the need to construct a flow map of existing flows is highlighted. This refers to the flow of energy, water, biomass, metals. The flows are exclusively material, excluding the intangible flows and human dimension.

Most of the analysed cities recognize the importance of organizing, in general, the city's systems in analogy to the organization of natural systems (where "nothing is waste"). As emerged from the analysis of these circular cities, the attention is mainly focused on material and energy flows. The strategic actions are mainly related to the production of goods and services (product design, eco-design and use of eco-compatible materials, eco-compatible production processes, etc.), to the prolongation of the use value of resources (through reuse, repair, etc.) and waste management. In particular they are referred to:

- a built environment designed in a modular and flexible way;
- renewable energy systems and efficient use of energy;
- accessible, economical, clean and effective urban mobility system;
- recycling and transformation of waste into a resource;
- production systems that encourage local loop closure and waste minimization.

Each of these cities is concentrating their strategies and actions mainly on the sectors in which the material flows are greater. For example, Amsterdam is focusing on construction chain and organic residual stream chains considering actions related to smart deign, material recycling and reuse. London is concentrating on built environment, food, plastics with attention on reuse, design, minimizing waste. Glasgow is focusing on healthcare, education and manufacturing sectors, implementing actions able, for example, to reduce waste, transforming waste of an activity/industry in nutrients for another one. In the city of

Rotterdam the actions are mainly referred to the management of residual material flows of medical, food, clean tech/maritime, construction sectors.
Paris developed a White Paper with 65 circular initiatives in connection with metropolitan planning, identifying strategies and related actions referred to different field, as encourage product eco-design, create new business parks for circular economy, integrate a recoverable energy vision in land planning, create an on-line information platform for the circular economy, reduce the use of disposable packaging, renovate rather than demolish. Most of them are referred to material reuse, using of renewable energy and minimizing waste.
As emerged from the analysed case study (particularly in the case of Paris and Antwerp), urban planning plays a fundamental role. It contributes to stimulate circular/virtuous processes at different levels (neighbourhood, urban and territorial, between the city and the rural territory) through a systemic approach and evoking the approaches and tools of industrial ecology (strong attention is focused on the analysis of flows between city and territory, urban metabolism, synergistic exchanges between flows of resources possible thanks to spatial/geographical proximity). Urban planning can therefore significantly contribute to trigger flows of energy, materials, services, people to catalyse economic development (and not only).
The necessity to engage citizens in urban planning is an element that emerges from case studies. In particular in the city of Antwerp through the Circular South project (www.uia-initiative.eu).
The reuse of unused, abandoned and resulting spaces through urban planning can play a strategic role in the implementation of this new city model. Their reuse is in line with the principles of circular economy (reducing waste and prolonging the use value of resources) and can also represent the physical space in which to activate new flows (i.e. Amsterdam and Glasgow that start from vacant land and empty building). Therefore the places of abandonment and marginality play a strategic role, becoming key places for urban transformation/regeneration (in coherence with the "leave no one behind" principle of the Agenda 2030 - understood both in reference to man and to places – and with the New Urban Agenda). From this perspective, the reuse of abandoned real estate assets, unused public assets, and abandoned industrial areas can also be considered.
There are also some "elements" of the city that can play key role in the implementation of the circular city model, becoming cyclifier, that is a trigger point of flows (Fusco Girard *et al.*, 2014; Fusco and Nocca, 2016). For example, in the city of Antwerp the port (one of the largest ports in the European Union) is recognized as a key area for the implementation of this model. It is recognized as the perfect place to apply the principles of the circular economy (www.sustainableportofantwerp.com).
The city of Antwerp is greatly investing in the circular economy starting from the port. Here, in fact, with so many companies (operating in different sectors) working in such proximity to each other, there are a lot of opportunities for jointly using sites or reusing a company's by-products and waste as raw materials in another company. Residual heat is transformed into heating, wood chips into biomass and so on.
The municipal administration is a key player to promote the above considerations in urban planning. So, a circular city requires an integrated vision/management of the many existing planning tools at the municipal level.
In all the case studies, the relationship between the circular economy and the production of jobs is highlighted, specifying indicators relating to employment. This highlights the

contribution of this new model to the improvement of quality of life. Employment is a key word related also to wellbeing concept: it contributes to make people "feel good", not only because of economic aspects, but because it let people be in relationship each other.
The adjective "smart" recurs several times in the case studies (in particular in Amsterdam and Rotterdam) in relation to the implementation of the circular city. This adjective is intended exclusively with reference to the use of technologies (sensors, digital platforms, etc.). ICT and innovative technologies are certainly fundamental tools for the city to become a "circular city", but they are a mean and not the aim. They are important for the circularization of processes, but they require a strong cultural base – culture – (often recalled in the analyzed case studies), "mirror" of how people live and work by organizing their behaviour in a circular or linear way. The "technological aspect" of the circular city, as it emerges from the case studies, could exclude a part of community from its implementation (for example in relation to the use of technologies such as sensors, digital platforms, etc. not easily accessible and usable by everyone – seniors, children and the disabled, etc.). Instead, everyone should be able to take an active part in the creation of a circular city.
Furthermore, the adjective "smart", in addition to referring to the use of technologies, should also refers to the wise (creative and efficient) use of resources in order to optimize the efficiency and effectiveness of processes and services of a city. Smartness is not synonymous with technology.
It is recognized that the successful transition towards the circular city model requires behavioural changes, for which society as a whole needs to be addressed. Those lifestyle changes, in turn, depend on citizen awareness of the issue. There is a need of a "cultural revolution". This is the reason why, for example, the city of Antwerp is implementing innovative approach for engaging its citizens and raising their awareness about consumption and encourage circular lifestyles (using for example smart technologies and personal dashboard that displays real-time data-flows of water, waste bin and energy meters allowing citizens to comprehend their flows. This aspect, although considered in many circular cities, is not so highlighted in their reports, while more and more space is left to the technical aspects of the circularization.

5. Challenges in the circular city model implementation

To date, a clear definition of circular city doesn't exist and there are many discussions around this definition. Decoupling resource consumption from production and economic growth surely represents the first objective of a circular city, as also emerges from analysed case studies.
However, the circular city should be more than a sum of circular economy projects and more of a model for urban consumption and production. It should consider also other issues as community engagement and participation, social and environmental justice, intergenerational equity (Williams, 2019).
Thus, a clear definition of the circular city surely represents a first challenge in order to identify appropriate goals, strategies, policies and tools.
The key challenges to the implementation of the circular city model are cultural, economic, political, regulatory, institutional, physical and informational (Tab. 3) (Williams, 2019).
The inflexibility of institutions and their lack of engagement with civil society in local service delivery represent great challenges to the successful circular transformation.

The restructuring of the macro-economy and shift in cultural values required to implement the circular city model creates a great inertia to change. Inadequate political leadership, the erosion of municipal competencies and resources also represent a challenge (www.circularcitieshub.com).
Another important challenge is represented by the need to adjust the regulatory framework to the objectives of the actors to implement the circular city agenda. A lack of supportive regulatory framework is a real problem in aligning actor goals to implement the circular city agenda.
A lack of useful data for monitoring resource flows, the multidimensional impacts of this model on city productivity and for changing actor behaviour also represent a problematic issue.

Tab. 3 – The challenges to circular transformations:

CHALLENGES	DESCRIPTION
Culture	Norms, ideas, customs and social behaviour of people
Economy	Production, distribution and consumption of goods and services
Physical environmental	Natural and built environment
Political and leadership	Policy preferences, issues of government and leadership
Smart	Data, information, monitoring, knowledge
Institutional	Organizational structures, cultures and practices
Regulatory	Regulations, regulatory instruments and policies

Source: Circular Cities Hub (www.circularcitieshub.com)

Another big challenge to implement the circular city model is related to financial aspects. How do we finance this transition and implementation?
Considering the limited availability of public funds, new tools for financing circular cities should be identified (i.e. scope tax, crowdfunding, municipal bonds, etc.).
It is necessary to guarantee a more effective financial base at city level, through new Public-Private-Partnerships, able to engage in a win-win strategy all stakeholders (also academic institutions, third sector associations, social entrepreneurs, etc.), innovative financial tools able to reduce the gap between the (many) needed resources and the ones concretely available (few), a strong/rigorous coordination between national tax return and local internal tax revenue, to avoid local insolvency/collapse. Furthermore, tax revenue systems based on land value should be transparent, open, agreed and participated, so that all local communities can check and assess in the public framework. All the stakeholders should be put in condition to participate to become aware of costs and financial returns. All financial tools and processes at local level should be put in strong relationships with planning processes.
As said before, although the above mentioned examples of circular cities, a general and recognized definition of circular city is still lacking. So, it represents the first challenge.
Most definitions link the concept of the circular city to waste flow and to an indefinite enlargement of the lifetime of resources as long as possible. But a circular city is not only

related to waste management or energy flow.
Surely, a circular city cannot be considered a simple sum of circular economy projects. "A circular city should include more than the sum or multiplication of urban circular economies. Nevertheless, prevailing discourses remain till today business focused, and how circular economy creates economic, social, and environmental resilience in cities has yet to be explored" (Marin and De Meulder; 2018).
The consumption of resources (materials, energy, water, buildings and land) can be tackled by creating circularity in resource flows in urban systems both in the city's life-cycle and within the city-region. Systems integration, flexibility, intelligence, cooperative behaviour, localisation, recycling and renewable resources are the key concepts at the base of the Circular City. In particular, in a circular city resources can be cycled between urban activities and within city regions and resources can be reused/recycled over time (Tab. 1, Tab. 2).
In the circular city the production of value "shifts from production and ownership of goods to their sharing, from ownership to access, from purchase to reuse" (i.e. in London where manufacturers and retailers are increasingly looking to new business models that enable sharing, renting, leasing and more). Sharing, renting, leasing become key words in the circular city. But are we ready to welcome these new trends? Are they for all or only a part of the population (young people, etc.)?
The circular model goes beyond the singular actor (i.e. company). Its inclusive approach involves multiple and different actors to participate (citizens, associations, local authorities and companies). It needs to put in a synergic relationship all actors involved in this challenge and to create a network to accelerate the transition towards circularity.
Furthermore, the implementation of circular economy model necessarily requires investment in technology, innovation and knowledge that are linked to some identified functions (Circle Economy, 2016b). It needs to include "circular thinking" in political and socio-cultural level (Gemeente Rotterdam, 2016).
The resources necessary for the implementation of a circular city are both tangible (transport infrastructure, energy and natural resources) and intangible (human capital, education and knowledge, and intellectual capital of companies).
The circular city is not just an issue related to technological innovation, to material flows or to reuse and recycling of waste (it would be a key to reading that is too sterile and limiting). The technological innovation is only a part of it.
We must not forget to consider the human dimension according to the paradigm shift underlined in particular in the paragraph 26 of the New Urban Agenda that is characterizing the humanization of our cities. This human dimension rarely emerges from analysed reports. The circular economy needs to be more inclusive putting the human being at the core of its processes. If we think about how to design or how to trigger circular processes without considering human needs, "circular outcomes might not be the expected ones." Circular human flow has to be integrated into the "butterfly diagram" (Ellen MacArthur Foundation, 2015) in order to preserve and enhance human value (Lemille, 2017). There is a strong belief that a social dimension would be needed as an integral part of the powerful circular economic framework to preserve and enhance human value. It is necessary to consider human needs as the goal/core of the economic framework allow having a healthier economy.
So, the human dimension must be considered in the implementation of the circular city. The

"heart" is represented by relationships and synergies. The "protagonist" of the circular city is not the single person or the single enterprise, but the community, a group of subjects that collaborate and cooperate, having a common goal. All the actors and stakeholders have the potential to influence the processes and decisions (and thus have responsibility).

6. The role of cultural heritage and port area in circular city implementation

Cultural heritage and port area (as emerges, for example, from the Antwerp, Rotterdam, Marseille, Amsterdam case studies) can represent two significant starting points for the circular city model implementation.

As highlighted above, in the circular approach resources are re-used, recycled, recovered, regenerate and shared. Among resources, cultural heritage/landscape is not considered in case studies, although it can represent an entry point (a "cyclifier") for the circular city model implementation.

Adopting a circular model means to understand the complex relationships among different values of the resources and the role and needs of different stakeholders. In the landscape perspective, the circular economy allows conserving the use-value (through the regeneration of resources) and intrinsic values of heritage.

The reuse, rehabilitation, restoration of cultural heritage and cultural landscape are part of the circular economy processes. In fact, there is a close relationship between the conservation of cultural heritage (through its functional reuse) and the circular economy. Both of them aim to extend the life cycle of the building as much as possible. The reuse of cultural heritage takes place through circular economy processes and, vice versa, one of the sectors through which the circular economy can be implemented is represented by the cultural heritage/landscape conservation.

Cultural heritage conservation/valorization and circular economy are intertwined because they both prolong the use values in an indefinite time. Thus: cultural heritage conservation can be implemented through circular economy and circular economy can be implemented through cultural heritage conservation/valorization. In this way, multidimensional benefits are produced: cultural benefits (conserving "alive" a symbol of community identity), economic benefits (in terms of increase of productivity), environmental benefits (i.e. reduction of resource consumption) and social benefits (i.e. employment).

Port cities and port areas also have a particular development potential and can assume an important role to achieve sustainable development and implement the circular city model, combining in a circular and synergistic approach port economy, logistic, industrial activities with cultural heritage/landscape regeneration (starting from local cultural resources). Port cities become cities of symbioses: symbiosis between industrial/logistic economy and touristic economy, industrial system and urban system, cultural heritage/landscape conservation and economic development, etc. (Fusco Girard, 2013).

Port cities offer a lot of opportunities (i.e. in Amsterdam and Rotterdam ports) to make circular economy concrete, through recycling, sharing, re-using, designing, up-cycling (Fusco Girard, 2013).

Port area is the place where flows are maximized; for example, it is the place where many flows of the globalized economy arrive at and depart from, the focal point that connects every country in the world. Commercial, industrial, logistic, tourist and fishing activities are concentrated in port area, making it a driving force for economic wealth.

Many cities are starting from the port to implement the circular model (Rotterdam,

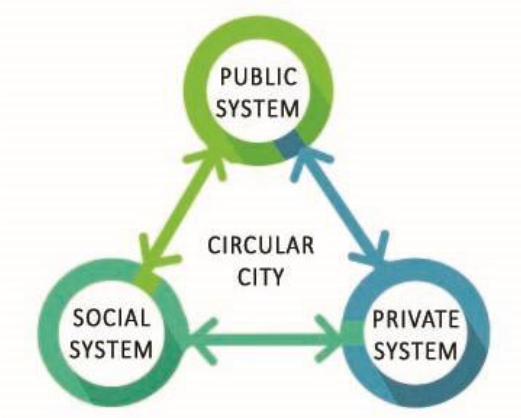
Amsterdam, Marseille, Antwerp, etc.). Each port authority of these cities has its own policy to make circular economy principles operational, on the base of the port profile (Vermeulen, 2016).
Port areas contribute to the particular beauty of a landscape which expresses the combination of human and natural creativity and contribute to the identity of the city. Landscape is playing an increasingly central role in economic global competition. In fact, the majority of the most beautiful urban landscapes all over the world are port cities/areas: Bergen, Venice, Genoa, Istanbul, Liverpool, Malta, Naples, Oporto, Saint Petersburg, etc.
The quality of natural and cultural landscape is important for regeneration processes, but it alone is not enough. It has to be integrated with human and social landscape that is able to trigger virtuous circularization processes and synergies, contributing to the human dimension of urbanization (Fusco Girard, 2013). Port and city have different interests and priorities, so it needs to search for solutions able to create synergies between them. It needs to find solutions able to increase port-city ecosystem productivity (in a multidimensional way). So, port area can be a *cyclifier* for the circular city model implementation, a trigger point of flows (Fusco Girard and Nocca, 2016).

7. Integrated evaluation tools for assessing the circular city

In order to overcome criticism related to circular economy concept - that is quite "idealistic, not linking up to normative expectations, without social consideration" (Prendeville *et al.*, 2018) – and thus to produce empirical data about how cities are implementing the circular model, it needs to identify tools to pave the way towards this new model.
In the transition towards the circular city, tools (as evaluation, governance, financial tools) play a fundamental role.
The attention is here concentrated on the evaluation tools for evaluating and monitoring the efficiency/effectiveness of the circular cities, that is to assess (positive and/or negative) impacts of projects and initiatives of the circular city agenda.
Circular cities are a new phenomenon and, to date, it is very difficult to build empirical evidence of their success (or failure): to date, "evaluating" the success or failure of a circular city is a complicated process, above all because many initiatives are in an initial stage (and so, for example, there is still a lack of data).
The evaluation of the different scenarios, analyzing for example the impacts of the same process/project organized both according to a linear logic and circular one, would help to demonstrate the benefits deriving from this new model and thus accelerate the transition. To this end, for example, in the White Paper of Paris (Mairie De Paris, 2017), the analysis of the different scenarios related to the demolition and reconstruction of buildings with reference to financial, social and environmental impacts is proposed in order to demonstrate the convenience of the king of projects.
From case studies some indicators emerge, but to-date the indicators identified to assess the circular economy projects are mainly focus on technical flows and materials cycles because "their circularity" and benefits of associated businesses are easier to understand. Furthermore, a set of recognized indicators doesn't exist. They are mainly specific for industries and production chain (as emerged from case studies, London, Antwerp, Glasgow, Amsterdam, etc.). But, before to identify and examine the indicators, it is necessary to analysed the general evaluation framework of the circular city and to identify the main goal, the objectives and the attributes.

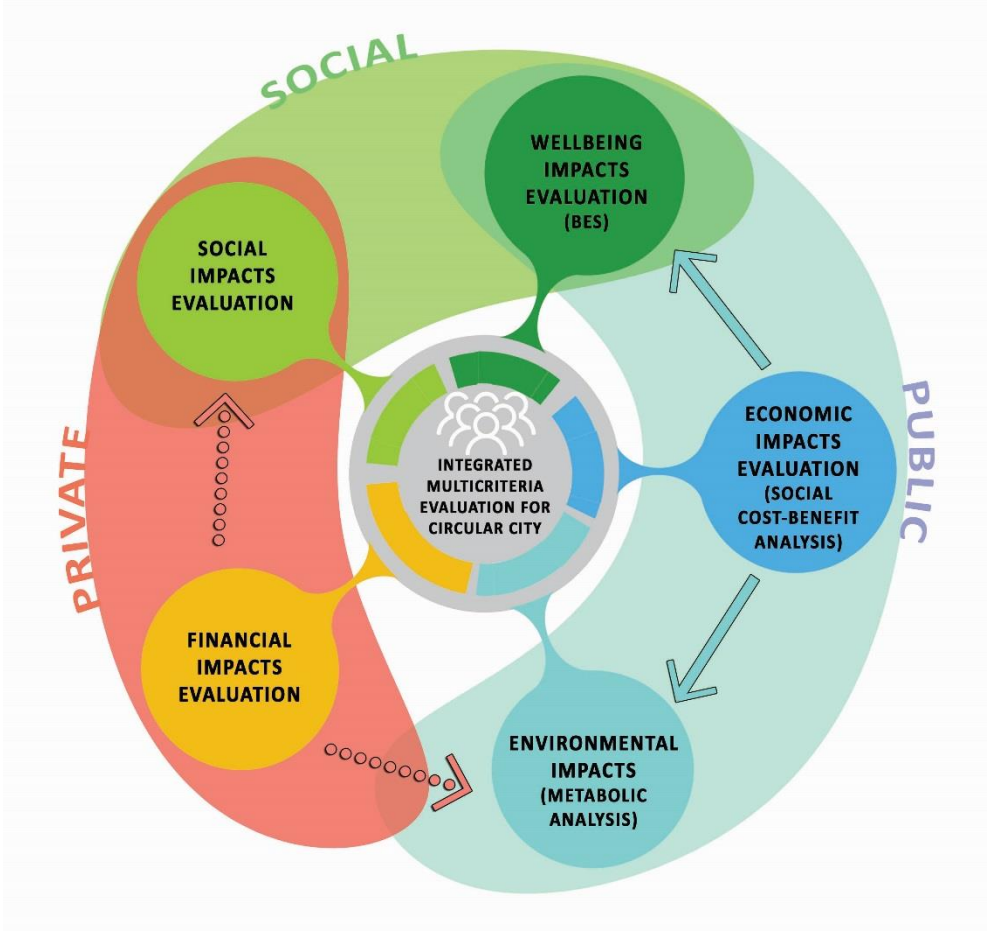
New evaluation tools are fundamental both for evaluating circular strategy implementation and for monitoring the "journey" towards this new model. Considering the (long) time that the transition process can take (as EPA Network underlines), we need to assess both the transition process and the achievement of the circular model. In this way, it is possible to understand if the city is going in the right direction or if additional measures are necessary.
For both above-mentioned phases, we need to assess the "circularity level" (i.e. ratio between the total of saved material and the total consumed material) and the impacts that the "circularity" produces (environmental and socio-economic effects, i.e. cost reduction, employment, etc.). Ex-post evaluations become fundamental also as they allow evaluating and "communicating to the various stakeholders" the effectiveness of the implemented strategies and projects.
The circular model implementation necessarily requires an integrated evaluation tool able to capture the multidimensional impacts that it is able to produce and considering all the subjects/actors involved in its implementation, that is a multicriteria, multi-group, quanti-qualitative, short and long term evaluation tool. It is necessary an evaluation tool able to integrate the economy dimension with the environmental, social and cultural ones.
The circular city is organized on three "pillars": public, private, social (Fig. 1). The circular city model requires the "entrance" of another system, in addition to the public and the private systems: the third sector, the civil society.

Fig. 1 – The circular city systems



In evaluation terms, it is "translated" into the integration of evaluation models that concern these three different systems. We need an evaluation tool that integrates "traditional tools" that were born and are used in the linear economy field with tools characterized by a matrix linked to the circular economy model.
The three systems (public, private, social) that have to be considered and integrated, or better yet "hybridized", into the evaluation tool for the circular city model are (Fig. 2): public, private, social.

Fig. 2 – The integrated evaluation framework for circular city



- Public: this point of view is the traditional one mainly focused on the economic evaluation and social cost-benefit analysis. This perspective is then extended to the assessment of wellbeing and environmental impacts (that is to the analysis of urban metabolism). The circular economy contributes to transforming linear urban metabolism into a new circular urban metabolism, in which input and output flows are "closed". So, the analysis of urban metabolism can provide a framework for assessing and monitoring the transition to the circularization of urban processes (processes within the city and between city and territory).
- Private: this point of view is mainly focused on the financial impacts evaluation. But this perspective is going to be extended to the social dimension, considered for example the behaviour of some entrepreneurs (i.e. Olivetti, Ferrero, Bata).
- The entrepreneurs, in pursuing their entrepreneurial objectives for their own wellbeing and business, move towards the realization of the common good and transformation society. Today, the business world (profit and non-profit enterprises) is not able to give

evidence to the social value that it is able to produce. Only some entrepreneurs, as the above mentioned Olivetti, Bata and Ferrero, have understood the importance of the added social value produced by their own entrepreneurial activity and have given evidence, pursuing "that great project of social commitment known as welfare capitalism" (Zamagni *et al*., 2015). So, also this system (private) is going to extend to social impacts and wellbeing evaluation. Furthermore, the private system is going to pay attention also to the environmental impacts. He is attentive to the territory and the environment reducing negative impacts coming from productive processes. Some entrepreneurs are increasingly making aware choices towards the ecosystem. This awareness and need to respect the environment are also influencing their choices.

- Social: the third sector becomes, together with the public and private, one of the actors of the circular city. The social sector is interested in particular in the production of social capital. So, this area is mainly focused on the evaluation of impacts on social capital. The impacts that this sector is able to produce should also be considered in the circular city evaluation framework. The social impacts assessment refers to the qualitative and quantitative evaluation, in the medium and long term, of the impacts of the activities on the community. The social enterprises contribute to the production of wellbeing for the communities and territories in which they are placed.
- The third sector transformed from redistributive sector into productive sector, producing added value in social, cultural, economic and institutional terms (Zamagni *et al*., 2015).
- So, as the third sector becomes an important actor in the circular city, it is necessary to consider both the impacts produced on social capital and the impacts produced by social enterprises on the other dimensions, as economic, cultural, environmental impacts.

These integrated assessments are both quantitative and qualitative, as subjective and perception indicators must also be considered, including an appropriate set of criteria and indicators that differs passing from the macro scale (metropolitan city) to meso-scale (historic district) and micro-scale (single sites or building).

8. Towards new research in evaluation field

Circular processes produce multidimensional impacts and the evaluation framework linked to circular economy represents a fertile and interesting field of research. An integrated evaluation tool, that is a multicriteria, multi-group, quanti-qualitative, short and long term evaluation tool, is absolutely necessary. It is necessary to demonstrate the multidimensional benefits of the circular economy and the circular city model in order to convince policy-makers/community/companies that investing on it is convenient. For example, economic circular processes reduce negative impacts on the environment and, at the same time, on the differential and Marxian rent, thus avoiding/reducing the use of natural and man-made capital (Fusco Girard *et al*., 2019).

In particular, the circular economy has impacts on the real estate market:

- the reduction of underused land thanks to the circular economy principles implementation reduces the rent in city center because of the redistributive phenomenon;
- the more the building/space functions are flexible, the more the real estate value increases as the adaptation costs are reduced in the long term;
- the use of renewable resources produces a "delta" of the real estate value as it produces a reduction in management costs. The use of materials that allow improving the comfort

inside the buildings has positive impacts on the health and well-being of the people living there determining, consequently, a plus real estate value.

Another issue related to the evaluation processes linked to the circular processes is referred to social capital. As underlined in the previous paragraph, the circular economy is based on a systemic approach and thus on the density of relationships. How can we include the value of these relationships in the evaluation process? How to assess them? What are the criteria for expressing these conditions?

The circular economy is able to reduce the "waste" of capital. Among the different forms of capital, there is also the social capital. How do we assess this social capital?

The circular model thus represents an interesting open field of research, to date still little explored. In this framework, it is necessary to begin to compare starting from empirical evidence, that is, from ex-post evaluations.

9. Conclusions

As above highlighted, the circular city is to date still open concept for debate, that is identified by different perspectives in literature and in practice. Although some cities are implementing the circular model, there is still ambiguity around this concept. Consequently, the debate and the research around tools to implement it represents a fertile activity.

Surely the circular city cannot be considered a sum of circular economy projects and a model only related to waste management and enlargement of the lifetime of resources as long as possible. It would be too much a simplification of the concept.

The technology is a mean and not the aim of the model. The "heart" of the circular city is represented by relationships and synergies. The human being has a central role. According to the paradigm shift (human scale of development), the human dimension (and thus the human social capitals) plays a key role in implementing the circular city model. The success of the implementation surely depends on human behaviour.

Putting the human being at the core of the circular city model requires investments in research, but also investment in cultures for changing the mindset and the lifestyles by bottom-up. This challenge requires specific strategic development plans, financial tools, etc. but also a *strategic plan for culture.* This strategic plan for culture is grounded on enhancing competence and the capacity of critical thinking by each subject stimulating a circular way of thinking. This circular/relational rationality improves responsibility. Considering that responsibility is based on evaluation of impacts of each action and that critical thinking is the pre-condition for responsibility, the key characteristic of the strategic plan for culture is to be recognized in the evaluation capacity by each citizen.

Appropriate tools to face the above identified key challenges to the implementation of circular cities are required.

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