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INVESTIGATING CIRCULAR ECONOMY URBAN PRACTICES IN CENTOCELLE, ROME DISTRICT

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Abstract

The embedment of circular economy principles in cities is an opportunity to reduce the urban waste production and resource consumption towards closed-loop systems. In particular, the adoption of circular economy strategies as regeneration, optimization, sharing and loops can overcome waste and inefficiencies of linear economy. This paper presents some circular economy practices bringing an integration of circular strategies at urban scale. This work was funded by the Research into Electrical Systems Italian National Programme aimed at implementing a Smart District Models. The research project has been carried out in an Italian demonstrator quarter: Centocelle located in the city of Rome. Thanks to the smart solutions employment, a collaborative process has been established involving citizen. As a result, several circular economy urban practices have been identified supporting the smart community growth. The combination of smart community experience and circular economy principles application has resulted in several mutual advantages. In particular, the identified circular practices, as community gardens, co-workings, local and km0 production systems, recycling centres and other experiences of waste management, have achieved an urban transformation in terms of regeneration, sharing economy experiences, resource optimization, closed-loop systems. Therefore, circular economy practices have positively and actively influenced the urban community supporting the transition towards circular economy models.

Key words: circular economy, smart district, smart community, urban regeneration, waste prevention

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1. Introduction

Approximately the 70% of the European Union population live in urban areas (EC, 2016). The share of population in cities continues to grow, and it is likely to reach more than 80% by 2050 (World Bank, 2019). Population density, urbanization process and economic activities intensify both environmental and social issues (ISWA, 2018). Cities are therefore facing correlated and complex challenges in terms of climate change, environmental pollution, waste production, economic development, occupation, demography, migration etc. (World Bank, 2010). But urban areas are also placing of innovative transformation, incubators of new concepts and ideas, steering both global and local economy and furthermore creating

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opportunity for job and wellbeing. Cities are so dynamic places where change can happen on a larger scale and at a more rapid pace, and they are also privileged places.

This paper focuses on urban transition towards Circular Economy (CE). Actually, there is the need to prioritize a systematic transition from the linear paradigm of production and consumption towards a circular economy model (EMF, 2017). According to EMF (2019), CE in cities should be based on the following three principles:

1. regenerating natural system, preserving and enhancing natural capital;
2. keeping products and materials in use and reducing virgin material pressures interactions;
3. designing out waste and pollution.

CE at urban level could act as a restorative and regenerative process. In particular, the first principle will encourage conditions for regeneration, such as soil for renewable resources. The second principle consists of keeping materials and products 'circulating' in the techno-sphere (McDonough and Braungart, 2009), through the efficient use, reuse, repair and sharing of goods (Geissdoerfer et al., 2017; Korhonen et al., 2018). Finally, the third principle is aimed at eliminating waste and reducing carbon emissions and pollution. In fact, CE promotes waste prevention one of the main strategic objectives of European waste management policy (EC Communication, 2015). According to the European Directive 2018/851 (EC Directive, 2018), which updated and replaced the original 2008/98/CE Directive (EC Directive, 2008), a waste hierarchy in the legislation and policies around waste management has been established and waste prevention has a priority position. In addition, a specific European waste prevention strategy is devoted to reduce plastic waste. Other CE consequences are related to climate change. In particular, it also renown that CE facilitates cutting down on GHG emissions, by reducing the amount of energy needed by production processes (Enkvist and Klevnas, 2018) and transforming primary raw materials into usable products (Iacovidou et al., 2017). Therefore, the application of CE principles in cities will allow fostering the challenge of transforming cities into circular aggregates. The CE principles adoption can be supported by the ReSOLVE model introduced by Ellen MacArthur Foundation (EMF, 2015) and consisting of the following six strategies: Regeneration, Sharing, Optimization, Loops, Virtualization and Exchange. In particular, regeneration concerns a broad set of actions that maintain and enhance the earth's biocapacity. Sharing strategy is aimed at getting a full use out of goods eliminating waste and duplication. Optimization is related to remove waste and inefficiencies in the life cycle phases of goods, such as manufacture, distribution, use, etc. Loop strategy is intended to process resources in order to close the cycle and put them back into the economy, rather than lost through landfill. Virtualization promotes a dematerialization of goods and products. Finally, exchange is the process of swapping in new technologies, upgrading or replacing older ways of doing things.

This study aims to investigate the application of CE strategies in a Smart Community through the collaboration of citizens and other urban stakeholders. In particular, the experimental activities have been carried out in the framework of an Italian national strategic research project funded by the Fund for Research into Electrical Systems (RSE project, 2019). One of the RSE project final objective (Project D.7 PAR 2015; Project D.6 PAR 2016-2017) is the development Smart Urban District integrated model and the implementation was carried out in a demonstrator district of the city of Rome, called Centocelle.

2. Experimenting CE in Smart Community: the Centocelle Case study

2.1. The role of Smart Community

According to Granelli (2012) a Smart City represents "a new kind of common good, a large technological and immaterial infrastructure that makes people and objects connect with each other, in a way that it integrates information and generates intelligence, it fosters inclusion and improves everyday life". In a smart city social, economic and environmental sustainability are closely related. The Italian Digital Agenda under article 20 of 221/2012 Act (Italian Law, 2012) defines a smart community as "a community built to form a connective structure, (open, aware and focused), and, at the same time, an adaptive structure, capable of generating data and knowledge and making one's behavior evolve". Furthermore, thanks to its local dimension, sustainability practices are more applicable in smart communities, whereas cannot be guaranteed in non-smart communities (Bifulco et al., 2016). Broader understanding of smart cities also highlights the use of modern technologies but sees them more as an enabler for better quality of life and decreased environmental impacts (IEEE, 2014). As an example, Marsal-Llacuna et al. (2015) suggest that smart city initiatives aim, by using data and information technologies, to "provide more efficient services to citizens, to monitor and optimize existing infrastructure, to increase collaboration amongst different economic actors and to encourage innovative business models in both private and public sectors". Another body of literature highlights – in addition to new technologies – the role of human capital in developing smart cities with improved economic, social and environmental sustainability (Ahvenniemi et al., 2017). This more holistic understanding suggests that smart cities allow the conjunction of governance, society and technology in order to bring the smartization process into urban economy, environment, mobility, lifestyle and population (IEEE, 2014).

This paper analyses some experimental activities contributing to a local Smart Community

establishment in Centocelle. In a Smart Community, citizens are able to act for the co-governance of the neighbourhood and to actively participate in the collective life (De Nictolis et al., 2017). In fact, several factors have an influence on pro-environmental behaviour (Buenrostro et al., 2014). In particular, the importance to build attitudes of belonging and co-responsibility has been highlighted (Hasan and Idris, 2014). Moreover, collaborative models offer opportunities to overcome linear approach (Sposato et al., 2017). In the RSE project, a co-creation process has been mainly developed related to innovative and smart solutions, based on Social Urban Network (SUN). In particular, the SUN consists of a coordinated set of interventions that has been developed both on the ICT technologies (social networks, web portal) and on the urban scene (interactive installation, local initiatives). This paper focuses on local initiatives based on the application of circular economy principles implemented in Centocelle through a strong citizen engagement.

2.2. CE practices in Centocelle District

Adopting a user-centric innovative approach based on Urban Living Labs (ULL) approach (McCormick and Hartmann, 2017), a collaborative process where citizens were actively engaged has been carried out within the Centocelle urban district (Cappellaro et al., 2019). Thanks to interactive workshops and interviews, 14 CE practices have been identified. In particular, a first screening on CE practices has been realized during the ULL activities consisted of working groups and co-design activities coordinated by researchers. Further data were also gathered thanks to a questionnaire and personal interviews to CE practices reference person. In Table 1 a description of the identified CE practices is provided. This study aims to analyze CE practices identified in Centocelle district. Details related to each CE practices are reported in the paragraphs below.

Table 1. Circular economy practices in Centocelle District

CE practices	***Centocelle local initiative***
Community green garden	"Giorgio De Chirico" Park
	"Villa Flaviana" community garden
	"Centocelle" Park regeneration
	"Tor Sapienza" community garden
	"100 e a capo" community garden
	"Centocelle" community garden
	"ZappataRomana" Urban map of community gardens in Rome
Co-working	Coworking "L'Alveare"
	Coworking "FusoLab"
Zero-kilometre practices	Km0 restaurant "DOL – Di Origine Laziale"
	Local purchaising grup "GAS L'Alveare"
Water house practices	Water House "ACEA"
Smart waste management models	Second-hand market "Capannelle"
	"AMA" recycling centres

2.3. Community green gardens

Several CE practices identified in Centocelle are related to urban regeneration of green spaces. Actually, thanks to the Rome Municipality authorization, citizens are allowed to convert these areas into a garden where to grow fruit and other vegetables, as plants and flowers. During the RSE project, three community gardens have provided data on their area dimension, as reported in Table 2.

Table 2. Data collection of Centocelle Community gardens

Community gardens	***Short description***	***Dimension of green area (m^2)***
"100 e a capo" community garden	Small community garden with plants and flowers	900
"Centocelle Public park"	Public park with a small education garden	6.000
"Tor Sapienza" community garden	Small community garden with fruits and vegetables	840

2.4. Co-workings

Other CE practices identified during the RSE project have been related to co-working. Coworking is becoming a new way of conceive work, especially in the larger urban centers which allow an economical and shared use of workspaces (individual workstations and meeting rooms) within an equipped and organized facility (internet access, printers, kitchens, relaxation areas, etc.). In Centocelle, two co-workings have been identified: L'Alveare and Fuso-Lab. Data on workstations provided by both Centocelle co-workings has been collected in Table 3.

Table 3. Data collection on Centocelle Co-workings

Co-working	***Number of working stations***	***Other facilities***
L'Alveare	30	2 offices 1 meeting room 1 baby space 1 local food purchaising group 1 kids clothes exchange service
Fuso-Lab	20	1 single private room, 1meeting room, 1 space for training courses, 1 conference call-room 1 room for event, 1 cafetteria with relax area, 1 self-managed food point, 1 info-desk outdoor spaces.

2.5. km0 practices

Other CE practices identified in Ceentocelle are based on the zero-kilometer (Km0) culture, an approach that promote local products ensuring distrubution transport reduction. In particular, the RSE project has identified a Km0 restaurant and also a local purchasing group. The main characteristics of a Km0 restaurant are the food quality (controlled and recognized), the respect of food seasonality and the promotion of local products.

In this study, a Centocelle Km0 restaurant, called DOL (Di Origine Laziale), has been investigated. According to data provided by the DOL restaurant owner in an interview, most suppliers are located within 170 kilometres and about 60 meals are served every day. In particular, DOL restaurant promotes the quality of Lazio Region food and wine and spreads the concept of local and short supply chain. Even local purchasing groups are Km0 practices arranged directly by consumers who co-operate to favor small local producers, product quality and respect for the environment. These groups in Italy are known as Gruppo Acquisto Solidale (GAS). As described in Table 3, L'Alveare co-working provides a service of GAS.

In this group, the most sold products are especially local fruit and vegetables. According to data collected during an interview, a typical shopping composition is: 70% vegetables, 10% fruit, 10% dairy products and 10% meat. GAS suppliers are located no more than 100 kilometres distance and the amount of purchased products is 150 kg per week.

2.6. Water house

Another CE practice is the water house: a modern fountain delivering water from local water supply. Currently, 77 Water Houses have been installed in Rome, and they are managed by ACEA (ACEA, 2018): 22 water houses are located in the city districts and 55 water houses are across the province of Rome. Centocelle is located in the V Municipality district of the city of Rome. Unfortunately, in the V Municipality there is not a water house, but for our study we refer to the water houses in the closest municipalities: IV, VI and VII municipalities, whose data are reported in Table 4.

Table 4. Water House data collection

Water houses	***Litres of supplied water (l)***
IV municipality (177.000 inhabitants)	7.350
VI municipality (257.534 inhabitants)	2.100
VII municipality (307.607 inhabitants):	750

2.7. Recycling centres

Finally, other CE practices identified in Centocelle were related to waste reduction. Through these CE practices, waste are not to be disposed, but they are re-introduced in a new economic cycle (Mihajlov et al., 2015). Examples are recycling centres. According to Panaitescu and Bucuroiu (2014), recycling centres allow to reduce the amount of recyclable waste landfilled minimizing the environmental impacts.

Recycling centres are generally managed by municipality. In Rome, AMA, the municipal waste management agency, has opened recycling centers for bulky waste and WEEE to be sent for recovery. Moreover, AMA also organizes a special Sunday bulky waste collection, arranging special recycling points in all Rome City Districts, including Centocelle.

In this study, data on the recycling center of V Municipality of Rome, which includes the Centocelle district, has been analyzed. In 2017, the Recovery Centre collected 3.947 tons of material. Moreover, Sunday every 2 months, AMA is present in the V Municipality of Rome for the special collection of bulky material, wood and metal. During the RSE project, the municipal company AMA provided data on the type and quantity of waste materials collected in the Centocelle district and it emerged that in 2017, 67 tons of material were collected. In Table 5, details on collected waste composition, and quantity are reported. Details on waste destination are not currently available.

Table 5. Waste data for recycling center in V Municipality of Rome

Waste type	***Waste amount (tons/year)***
C&D waste (cement, brick and ceramic aggregates)	1.884
Wood	1.779
Metal	185
Biodegradable waste	72
Paper and cardboard	65
Bulky goods (doors, beds, sofas and furniture)	29
Total	4.014

Other CE practices reducing waste are second-hand market or reuse centre. In these centres, citizens who no longer need a good, instead of turning it into waste, they can leave or donate them. In Centocelle, a Second-hand market is named Capannelle and managed by an association but currently no data are available for this practice.

3. Results and discussion

From the previous paragraphs several CE practices have been emerged in Centocelle district: community garden, co-working, Km0 restaurant, local purchasing group, water house, recycling centre. In order to better explain how the application of CE principles affects positively the urban transformation, the identified CE practice can be connected to the six ReSOLVE strategies (EMF, 2015). In Fig. 1, CE

practices distribution on the basis of ReSOLVE strategies is described.

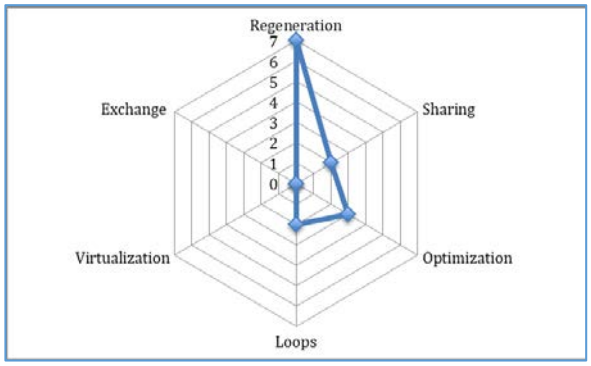

Fig. 1. ReSOLVE strategies application in Centocelle

From Fig. 1, it emerges that the majority of ReSOLVE strategies applied in Centocelle are related to regeneration, followed by optimization, sharing and loops strategies. No practices have been identified for virtualization and exchange. In the following, first results on CE benefits have been described for each CE strategies. According to the data collected in Section 2 and literature data derived by scientific papers and web sites, benefits in terms of CO_2eq emissions avoided, CO_2 emissions absorbed, waste reduction and prevention have been described.

3.1. Regeneration strategies

Most of Centocelle CE practices concern community gardens, which are initiatives generally aimed to regenerate urban degraded areas and transform them in green areas. Actually, green areas are the biggest carbon sinks in urban area. Carbon sinks are natural systems that suck up and store the greenhouse gas carbon dioxide from the atmosphere. According to a study carried out by Monito del Giardino (GR, 2014) the absorption of CO_2 in the Italian urban area each hectare of green area (consisting of a standard mixture of trees, shrubs and meadows of medium and high height) has an average absorption of 4.2 tons of CO_2 per year.

This value is within the range of other studies (Elmqvist et al., 2015). Therefore, the quantity of CO_2 emission absorbed by each community garden has been calculated (Table 6).

Table 6. CO_2 emission absorbed in community garden

Community gardens	***CO_2 emission absorbed per year (kg)***
"100 e a capo" community garden	378.0
"Centocelle Public park"	2.520.0
"Tor Sapienza" community garden	352.8

The community garden environmental benefits have been calculated on the basis of CO_2 emissions absorbed by the green area dimension (square meter). As a consequence, community gardens are CE practices allowing the enhancement of natural system in urban area.

3.2. Sharing

Another CE strategy applied at urban level is sharing and two co-workings are identified in Centocelle. Thanks to the sharing use, several benefits can be achieved by co-working compared to a traditional office. Different studies highlight these benefits in terms of CO_2eq emissions avoided for each working station service (Bolici et al., 2015; Swift et al., 2014). Data are summarized in Table 7. For the sharing use, it is assumed 1 equipment for 15 coworkers.

From the Table 7, the CO_2eq emissions avoided in a coworking are mainly due to a reduction in the demand for work mobility, mainly thanks to a greater proximity between users home and coworking (Padovani *et al.*, 2017). Other coworking advantages are related to the space use optimization, which implies a reduction of heating and electricity consumption (Rangone and Bertelè, 2012). Moreover, the sharing of equipment leads to significant reductions in energy consumption.

Table 7. Estimation of CO_2 emission avoided for co-working workstation

Coworking service advantages	***CO_2 emission avoided for workstation [kg CO_2 eq/year]***
Sharing use of: wifi, printers, coffee machine	123
Energy saving	180
Desk use increased (20%)	700
Carpooling from home to work	887
Total	**1.890**

3.3. Optimization

Other significant results have been achieved thanks to km0 practices, as restaurant and local purchasing groups (in Italy GAS). These CE practices apply optimization strategy through the promotion of local products. Generally, in supermarkets and other traditional stores, several products come from all over the world. It has been estimated that only the 20% of the energy needed to produce and market agri-food products is due to the agricultural sector and most of energy consumption are actually absorbed by processing, packaging, refrigeration, transport and distribution phases (DEFRA, 2017; Tukker et al., 2006). In particular, food transport has significant and growing impacts and it is an important factor affecting the environmental impact of food.

According to a study carried out by the main Italian farmers' organization (Coldiretti, 2011), in Italy a meal travels an average distance of 2,000 kilometers before reaching to the consumers table. According to these studies, km0 practices allow optimizing and reducing food transport impacts. As a

consequence, DOL km0 restaurant allows reducing about of 90% the food transport of a traditional restaurant.

Another “zero-kilometre" practice identified in Centocelle is water house. This CE practice applies the optimization strategies utilizing local water instead of mineral water. Different advantages are afferent to water house practices (Botto et al., 2011; Nessi et al., 2012). In this study the reduction of mineral water plastic bottles uses and, consequently, urban waste prevention has been emphasized for their connection to CE principles.

In particular, supplied water liters have been identified as reference flow for water house, and then it has been calculated the quantity of PET bottles (1.5 litres) avoided in the urban waste. In table 8, an estimation of waste prevention connected to the three water houses identified in Rome Municipalities close to Centocelle is reported. Data has been calculated on the basis following three assumptions:

- no water leaks are accounted, so the total amount of water supplied by water houses has been assumed for drinking use;
- avoided water bottles are considered of 1.5 liters PET bottles, according to Bevitalia (2018) it is the most packaging used in Italy;
- weight of PET water bottle is assumed of 28,7 g (Diercxsens, 2014).

Table 8. Plastic PET bottle and waste avoided by water house

Water houses	***Number of 1.5L PET Bottle Avoided***	***Plastic waste avoided (kg/year)***
IV municipality (177,000 inhabitants)	4.900	140.63
VI municipality (257,534 inhabitants)	1.400	40.18
VII municipality (307,607 inhabitants):	500	14.35
TOTAL	6.800	195.16

3.4. Loops

Finally, other CE practices identifies in Centocelle are related to loops strategy. In particular, thanks to recycling center practices, collected waste can be reused or transformed into secondary raw materials, reducing waste-related impact such as resources consumption, energy use and GHG emissions. Moreover, second-hand markets favor to reuse products that are in good condition and working. In this case, the goods life is extended avoiding the production of waste. In RSE project, only for the recycling center practices data were available, therefore the total amount has been calculated on the basis of the data collected and resulted in 4,014 tonnes of waste avoided.

3.5. Discussions

From the previous consideration, this study made a first attempt to identify benefits related to CE practices at urban level. This study has carried out a first screening based on data from literature related to climate change and waste production issue. For a deeper understanding of the whole impacts of cities’ activities (i.e. water consumption, atmospheric aerosol loading, chemical pollution, eutrophication, etc.), a detailed analysis according to decision support models (Ghinea and Gavrielescu, 2010) is needed in the future.

As final consideration, it can be affirmed that CE practices based on ReSOLVE strategies has revealed an opportunity for urban transition towards circular economy and in this process the Smart Community engagement process has played a crucial role. In particular, the Smart Urban network SUN has stimulated the local community in sharing information and expressing their ideas on CE practices. Moreover, applying CE at urban level has shown further implications in terms of urban district quality of life improvement and urban services effectiveness and efficiency. In particular, several socio-economic aspects are connected to CE application (Carolina et al., 2017; Ghisellini et al., 2016; Mihelcic et al., 2003). An example is the CE practice of community garden projects that were originally born especially for social purposes with the aim to aggregate citizens. Actually, community gardens are usually managed by citizens’ associations and several social activities are organized in them such as: gardening education, garden cultivation and recreational, sporting activities. Also, co-workings are characterized by services and facilities that can be related to social aspects. For example, in Centocelle, L’Alveare co-working offers also vocational training projects and social inclusion projects for migrant women living in the neighborhood.

Even the other Centocelle co-working, Fusolab, is managed by a social promotion association that promotes educational, cultural, technological and social projects for the benefit of the local community. Furthermore, second-hand markets are often connected to socio-economic aspects. In particular, second-hand spaces are generally managed either municipality or voluntary associations. In some case, volunteers can sell goods and earnings finance social projects. In other case, goods are selling for free or directly donate to poorer people. Moreover, the km0 practices can also produce important social-economic benefits, such as the promotion of local agricultural, culinary tradition and support to the local economy. Finally, other advantages are related to the water house practice.

Not only the plastic bottles use is avoided, but also, they produce economic advantages. Studies are estimating about in 130,00 euro/year for an average family (ISTAT, 2018). Therefore, the introduction of CE practices allows urban communities saving both

economic and environmental resources and also meeting social needs.

Conclusively, urban transition is a complex and systemic process and it cannot be achieved by any single actor. It will require collaborative efforts across the urban community, involving individuals, the private sector, different levels of government and civil society. Therefore, transforming cities into circular aggregates requires not only top-down traditional innovation approach, but also a collaborative approach based on user experience and co-creation. CE practices can promote systemic and collabortive change in society through the sharing of resources, the development of new skills and the co-creation of new urban communities.

4. Conclusions

Circular economy in cities is a challenging opportunity and this paper has described an experimental project carried in Centocelle Rome district aimed at implementing CE within a Smart District Model. In particular, co-creation interventions have been explored in collaboration with citizens and thanks to this experimental and collaborative approach, CE practices have been selected and studied. A particular focus was on the initiatives based to CE principles (as natural system regeneration, keeping materials in use and reducing waste and environmental pressures) developed in a Smart Community.

Thanks to the crucial role of citizens, placed at the centre of the innovation, the adoption of CE strategies, based on ReSOLVE model, were revealed more effective. As a consequence, positive results have been identified both in terms of environmental issues, and new socio-economic interactions. In particular, the application of ReSOLVE strategies such as regeneration, optimization, sharing and loops has brought benefits in terms of waste and carbon emission reduction. Moreover, CE practices at urban scale can also support the growth of new business opportunities and the development of new skills in urban community.

Therefore, CE urban practices have positively and actively influenced the local community real life, fostering a systemic transition towards circular economy.

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