Crossroads of the Concepts of Circular Economy and Smart City

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Abstract

Circular economy is a concept that is recognized as having a great potential in such global issue mitigation as climate change, loss of biodiversity, resource scarcity, deforestation, air water and soil pollution, etc. With the rapid development of information and communication technologies the concept of smart city has also gained the attention in scientific, political and business environment as well as in whole society. The objective of the article is to evaluate the similarities and differences between circular economy and smart city concepts. For this purpose authors used the methodology of literature review and qualitative content analysis. Results show that there are similarities between concepts of circular economy and smart city related to management of resources, resource efficiency, consumption, industrial symbiosis, renewable energy, sustainable development goals, sharing economy, business models and innovation. However, there are also differences between concepts as circular economy emphasises value preservation, systems thinking and life cycle thinking while concept of smart city emphasises technology, increased life quality, creativity, urban areas and security.

1. Introduction

Current way of operating has proved to be unsustainable – global population consumes the resources of 1.75 planets Earth (Global Footprint Network, 2019). That means that global society is using the resources today that are meant for satisfying the needs of tomorrow. Idealistic Sustainable Development Goals (SDGs) seem unreachable. Current way of operating does not include enough tools that could contribute to achievement of SDGs. Therefore, it is crucial to look at other concepts that could give us the opportunity to postpone the coming disaster forecasted by Meadows and Others (1972) related to limits of growth.

The beginnings of circular economy can be found in 1960s when American economist Kenneth Ewart Boulding drew an analogy from 'cowboy economy' to 'spaceship economy' (Geipele I. and Others, 2018, p.66). The concept of the circular economy is opposite to the traditional 'linear economy' that turns raw materials into waste in the production process (Zvirgzdins, Plotka and Geipele S., 2019, p.704). Circular economy is linked to such global initiatives as climate change mitigation and adaptation, reduction of fossil fuel exploitation and development of renewable energy sources (Zvirgzdins, Plotka and Geipele S., 2018, p.94). In the framework of circular economy any waste is considered a resource. Therefore, there is no term 'waste' within the concept of circular economy. Operating within this framework could provide global society with an opportunity to positively impact sustainability concerns related to resilience of resources. However, there is lack of tools that could possibly bring the concept of circular economy to life. Therefore, the attention of authors was attracted by smart city concept which in comparison to concept of circular economy is driven by technology and is practical in its essence. Present paper provides comparison of circular economy and smart city concepts revealing the similarities and differences between them.

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2. Methodology

To compare the concepts of circular economy and smart city, authors analysed the key words / characteristic elements of these concepts. Concerning the characteristic elements of the concept of circular economy authors used the results of previous research (Zvirgzdins and Geipele S., 2020). Concerning key words / characteristic elements of smart city concept 23 definitions of 'smart city' were analysed using the methodology of qualitative content analysis.

Qualitative content analysis is a widely used qualitative research method. This scientific approach is used to interpret meaning from the content of text data. (Hsieh and Shannonc, 2005, p.1277).

Identification of key words / characteristic elements of smart city concept was based on 23 definitions of 'smart city' (Bakici, Almirall and Wareham, 2013; Barrionuevo, Berrone and Ricart, 2012; Caragliu, Del Bo and Nijkamp, 2011; Chen, 2010; Cretu, 2012; Eger, 2009; Fernando and Others, 2011; Giffinger and Others, 2007; Guan, 2012; Hall, 2000; Harrison and Others, 2010; IDA, 2012; Komninos, 2011; Kourtit and Nijkamp, 2012; Kourtit, Nijkamp and Arribas, 2012; Lazaroiu and Roscia, 2012; Lombardi and Others, 2012; Marsal-Llacuna, Colomer-Llinàs and Meléndez-Frigola, 2015; Nam and Pardo, 2011; Thite, 2011; Thuzar, 2011; Washburn and Others, 2010; Zygiaris, 2013).
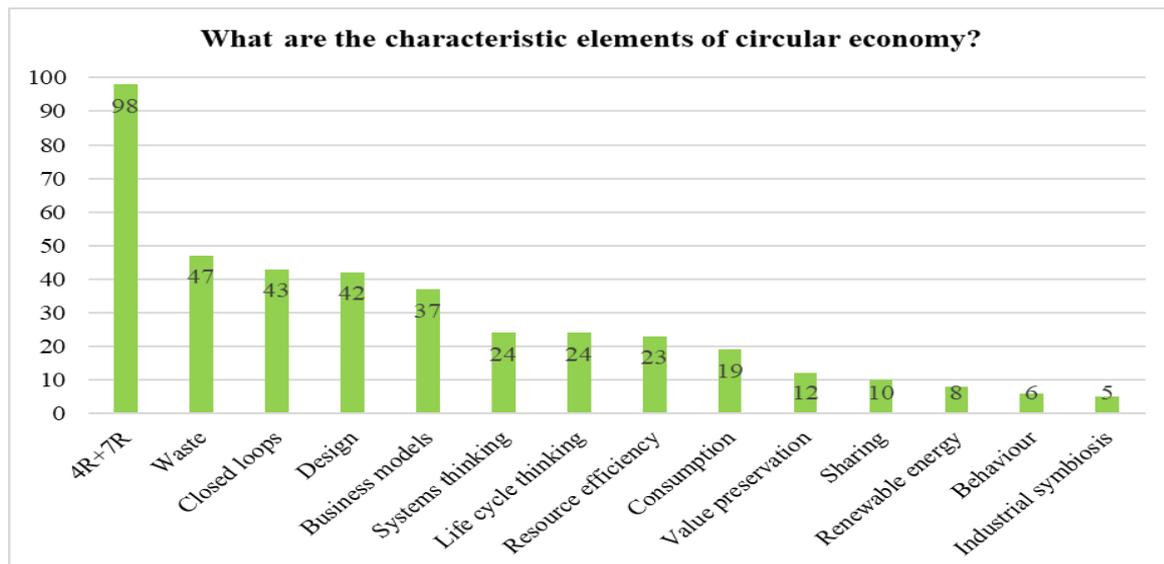
As a result of qualitative content analysis totality of 16 key words / characteristic elements related to smart city concept were identified as codes. From 16 codes 10 categories were developed.

3. Results and Discussion

At first, authors identified key words / characteristic elements of concepts of circular economy and smart city. Afterwards similarities and differences of these concepts were analysed. Based on the analysis conclusions were developed.

Characteristic elements of circular economy are reflected in figure 1 (Zvirgzdins and Geipele S., 2020, p.28). It can be seen that the characteristic elements of circular economy are the principle of multiple use and recovery '4R+7R', waste, closed-loops, design, business models, systems thinking, life cycle thinking, resource efficiency, consumption, value preservation, sharing, renewable energy, behaviour and industrial symbiosis.

Figure 1. Characteristic elements of circular economy (Zvirgzdins and Geipele S., 2020, p.28)

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Results of qualitative content analysis are shown in table 1 reflecting key words / characteristic elements of smart city concept. Totality of 10 categories were developed deriving from 16 codes. Categories are ranked in descending order based on their frequencies. The most common key words / characteristic elements of smart city concept are 'Sustainability' (11) and 'Technology' (11) followed by 'Resource efficiency' (8), 'Increased life quality' (7), 'Knowledge' (6), 'Data' (5), 'Management' (5), 'Creativity' (4), 'Innovation' (3) and 'Environmental benefits' (3). There were such codes that were not included into categories and they are 'Urban areas', 'Integration', 'Information exchange', 'Security', 'Energy conservation' and 'Business models'.
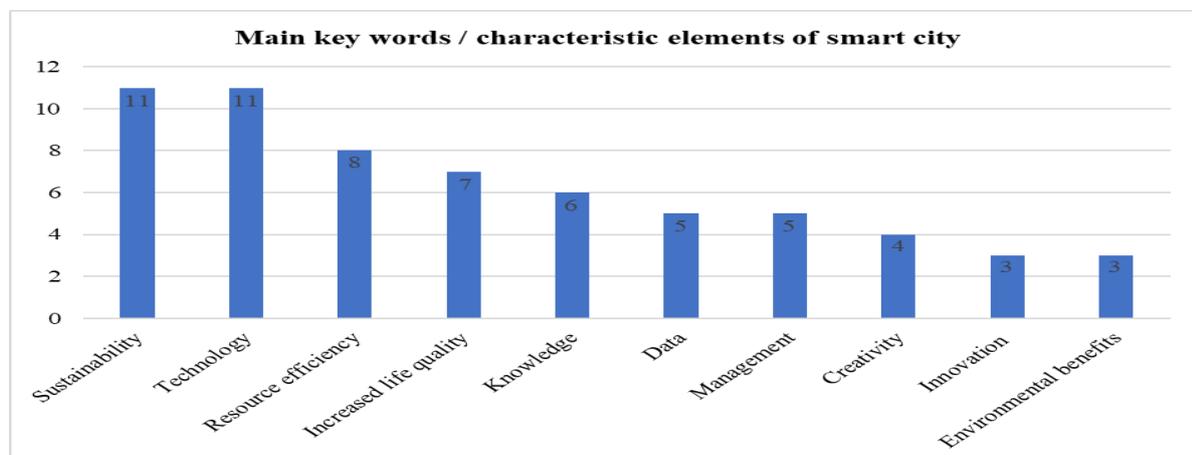
Table 1. Summary of categories and frequencies of key words / characteristic elements of smart city concept

Rank	Category	Frequency	%
1	Sustainability	11	17,5%
2	Technology	11	17,5%
3	Resource efficiency	8	12,7%
4	Increased life quality	7	11,1%
5	Knowledge	6	9,5%
6	Data	5	7,9%
7	Management	5	7,9%
8	Creativity	4	6,3%
9	Innovation	3	4,8%
10	Environmental benefits	3	4,8%
	Total	63	100,0%

Source: developed by authors

Data of table 1 is illustrated in figure 2, which emphasizes sustainability and technology as main key words / characteristic elements of smart city.

Figure 2. Category frequencies of key words / characteristic elements of smart city concept (developed by authors)

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To sum up, smart city concept is aimed at achieving sustainability through resource efficiency, knowledge, management of resources, assets, services, creativity and innovation. This concept is driven by technology, supported by data, and it increases life quality and provides environmental benefits.

Further authors analysed the similarities and differences of circular economy and smart city concepts.

Table 2 reflects similarities of circular economy and smart city concepts based on previous research (Zvirgzdins and Geipele S., 2020) and analysis described above.

Table 2. Similarities of circular economy and smart city concepts

Circular economy	Smart city
4R+7R; Waste; Closed loops	Management of resources
Resource efficiency	Resource efficiency
Behaviour, Consumption	Knowledge ('smart society')
Industrial symbiosis	Data; Information exchange (city as manufacturing centre)
Renewable energy	Energy conservation / Renewable energy
Sustainability (SDGs – 6,7,8,12,15)	Sustainability (SDG 11)
Sharing (change of ownership model)	Smart mobility (mobility as a service)
Business models	Business models
Innovation	Innovation

Source: developed by authors

Even though the key words / characteristic and approaches are different, it can be stated that concepts of circular economy and smart city are headed in one direction. Principle of multiple use and recovery, reduction of waste and waste management and closed loops in concept of circular economy are related to management of resources, assets, services in concept of smart city (see table 2). Behaviour and consumption that are characteristic elements of circular economy are in close relation to knowledge and 'smart society' which is not only adaptive to progress of technological level but also aware global environmental issues and their relation to consumption and consumer behaviour. There can be seen synergy effects between concepts of circular economy and smart city. For example, industrial symbiosis in which waste from one company serves as a resource for another (element of circular economy) requires information sharing among companies, and one of the elements in concept of smart city is data which could accelerate the information exchange. Additionally, city as a manufacturing centre could be the core of the intercompany clusters in industrial symbiosis, providing the conditions for sustainable business models. In the framework of circular economy all the required energy should be generated by renewable energy sources which is in accordance with smart city concept and code 'Energy conservation'. Both of analysed concepts are highly related to sustainability and sustainable development goals as circular economy is directly linked to Sustainable Development Goal (SDG) 6 (Clean water and sanitation), SDG 7 (Affordable and clean energy), SDG 8 (Decent work and economic growth), SDG 12 (Responsible consumption and production) and SDG 15 (Life on land) (Schroeder, Anggraeni and Weber, 2019), while smart city concept is directly linked to SDG 11 (Sustainable cities and communities). 'Sharing' is the characteristic element of circular economy which is derivative of the 'sharing economy' concept. It is based on a change of ownership from private to shared goods. One of the examples is car sharing which is linked to smart mobility and mobility as a service. One of the recent studies has shown that passenger vehicle sharing strategy applied to passenger vehicles in European Union (excluding Bulgaria, Cyprus, and Malta) has a potential to cut emissions by 358.6 $MtCO_2$ eq. and save 7.64 billion EUR annually (Zvirgzdins,

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Plotka and Geipele I., 2020, p.870). Additionally, circular economy and smart city both are aimed at resource efficiency, and both of these concepts require appropriate business models and innovations in order to be implemented in practice.

However, there are some differences between the concepts of circular economy and smart city as well. They are reflected in table 3.

Table 3. Differences between circular economy and smart city concepts

Circular Economy	Smart City
Life cycle thinking	Technology
Systems thinking	Increased life quality
Value preservation	Creativity
	Urban areas
	Security

Source: developed by authors

The concept of circular economy puts emphasis on lifecycle thinking, systems thinking and value preservation, while concept of smart city is driven by technology aiming to increase the life quality and ensure security in urban areas. Additionally, creativity is one of the characteristic elements of smart city concept, which is linked to creative society and creative solutions.

These differences between concepts of circular economy and smart city are the key aspect that could be exploited to create synergies and bring the society closer in achieving the sustainable development goals.

4. Conclusion

Key words / characteristic elements of smart city concept are sustainability, technology, resource efficiency, increased life quality, knowledge, data, management, creativity, innovation and environmental benefits.

Main similarities between concepts of circular economy and smart city are related to management of resources, resource efficiency, consumption, industrial symbiosis, renewable energy, sustainability and sustainable development goals, sharing economy, business models and innovation.

There are also differences between concepts of circular economy and smart city as circular economy emphasises value preservation, systems thinking and life cycle thinking while concept of smart city emphasises technology, increased life quality, creativity, urban areas and security. However, these differences have a potential to create synergies and bring the society closer in achieving the sustainable development goals.

Further research direction is linked to identifying and analysing other concepts, which could positively contribute to global issue solving and achievement of sustainable development goals.

Acknowledgement

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