

# WASTE MANAGEMENT IN THE CITY OF ORADEA - AN APPROACH IN THE LIGHT OF TRANSITION FROM A LINEAR TO A CIRCULAR ECONOMY

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**Abstract:** *Transition from the linear to the circular economy is not only a desideratum of all developed economies; it ultimately represents the chance for the world we all live in will to continue to exist. If in the first part of our paper we analysed the main characteristics of both the linear economy and the circular economy, in the light of an extensive literature, while focusing on the mechanisms that would allow a transition as smoothly as possible; in the second part of the paper, we aimed to analyse the state of play in the city of Oradea in terms of intelligent, selective waste management. Our analysis focused on two main strands: the selective collection of waste and the implementation of a recycling program for biodegradable waste. If in the first part of the analysis we came to the conclusion that it is necessary to involve all stakeholders, including public authorities, the private sector and civil society, in the second part we needed a statistical data analysis in order to be able to deeply understand the economic mechanisms behind the population' and businesses' behaviour. In that regard, we ran a statistical analysis of the amount of waste collected in the city of Oradea using the dedicated software SPSS 24 (Armonk); all outcomes were considered significant at a significance level of 0.05, while the connection between the variables was linear and of medium intensity. The conclusion we reach is that a positive evolution can be observed in the waste management following the implementation of the management system.*

**Keywords:** environmentally responsible behaviour, circular economy, waste management.

**JEL Classification:** Q38, Q53, Q55

## 1. Introduction

By analysing the document titled An EU Action Plan for the Circular Economy, presented in 2015, this paper aims to capture the challenges stemming from the

transition from a linear to a circular economy in the case of the waste management in city of Oradea. Traditionally, by the circular economy one understands a regenerative economic system where resources are used as efficiently and effectively as possible and waste is converted into resources. This system aims at reducing the impact on the environment and creating economic value. The Action Plan put forward by the European Commission also encompasses measures such as stimulating innovation, promoting standards for eco-design and sustainability, improving waste management and fostering the use of renewable energy. Moreover, clear objectives are set to reduce waste, as well as to increase the degree of recycling and reuse of materials. A significant focus is placed on the importance of collaboration between the EU Member States and the private sector to effectively implement the circular economy across the European Union. In addition, the use of both financial instruments and fiscal policy to stimulate investment in the circular economy is supported. Currently, at the EU level, there is a broad and detailed Action plan for the implementation of the circular economy, aiming to trigger economic and environmental benefits both through the effective use of resources and the transformation of waste into resources. However, one should analyse the extent to which this plan is to be implemented and which are the opportunities and challenges deriving from its implementation.

## **2. Theoretical and empirical aspects of the linear and the circular economy**

The linear economy and the circular economy are two different approaches to resource and waste management.

Waste management may be a concrete example in terms of the differences existing between the linear economy and the circular economy. In the linear economy, waste is considered a by-product of the production process and is mainly disposed of by landfilling or incineration. This approach leads to soil, water and air pollution, thus negatively impacting human health and the environment. In the circular economy, waste is considered a resource and is capitalized through recycling, reuse or energy recovery. For example, instead of throwing paper waste, this waste can be collected, recycled and turned into new paper or other products such as cardboard or paper packaging. This approach reduces pollution, protects natural resources and cuts production costs by making use of available resources in an effective manner. This example illustrates how the circular economy seeks to replace the "take-make, use and throw" process specific to linear economy with a circular model where resources are made use of in a sustainable and efficient way.

The linear economy is the traditional approach to resource management, which entails extracting raw materials, manufacturing goods, using them and subsequently disposing of them as waste. In this approach, resources are considered finite and used intensively, thus leading to their gradual depletion (Stiglitz et al., 2010, Nordhaus et al., 2006, World Bank, 2018)

The empirical aspects of linear economics include:

- Increasing resource consumption – as with the population increase and better living standards, consumption of resources has increased exponentially;
- Waste generation - the linear economy generates large amounts of waste with negative effects on the environment and human health;
- Resource depletion - intensive resource extraction and exploitation can lead to resource depletion.

With regard the theoretical aspects of the linear economy, they can be summarized as follows:

- Economic rationality - the linear economy is based on economic rationality, which assumes that resources are infinite and that their consumption must be maximized;
- Negative effects - the linear economy generates negative effects such as pollution and environmental degradation and such effects may impact the environment, human health or other aspects of social and economic life.

*The circular economy is an economic model aiming at streamlining the use of resources, by reducing and eliminating waste and waste emissions, by promoting the regeneration and reuse of materials, components and products, in a never-ending cycle of production and consumption (Kirchherr et al., 2017).*

*The circular economy term was used for the first time by the European Commission in 2015 (Gracia, 2020) (Lakatos, 2021): a system which maintains the value of products, materials and resources in the economy for as long as possible and minimises the generation of waste (Lakatos, 2021) (Eurostat, 2019).*

*Empirical aspects of the circular economy encompass the following: Effective use of resources - the circular economy encourages the sustainable use of resources, thereby reducing waste; Waste reduction - the circular economy focuses on recycling and reusing materials, thus reducing the amount of waste generated; Innovation and creativity - the circular economy fosters innovation and creativity to find sustainable and effective solutions for resource management (Ellen MacArthur Foundation, 2013; European Environment Agency, 2016).*

As far the theoretical aspects of the circular economy are concerned, they include the following: Life cycle - the circular economy is based on the concept of the life cycle

of products and services, thus encouraging the sustainable use of resource and reducing waste to a minimum; Integrated system - the circular economy approaches resource management in an integrated manner (McDonough et al., 2002; Bocken et al., 2014).

### **3. Need for a transition from a linear to a circular economy**

The circular economy is a regenerative and sustainable economic model in which resources are used efficiently and waste is considered as a resource and reinserted into the economic cycle through recycling and regeneration processes, so as to create a closed cycle of production and consumption (Ellen MacArthur Foundation, 2015) (European Commission, 2020) (Kirchherr et al., 2017). The transition from a linear to a circular economy means the transition from an economic model based on the extraction, production, use and disposal of resources and waste to a model based on their reduction, reuse, repair and recycling, in order to mitigate the impact on the environment and optimize the use of resources (Ellen MacArthur Foundation, 2013). In the circular economy, attempts are made to minimize the loss of resources and to maximize economic effectiveness through measures such as:

- Circular design, through which products are created so that they are easy to repair and recycle;
- Circular business model, which entails systems for renting, exchanging or selling products in order to reduce the need to purchase new resources;
- Sustainable management of resources, through which resources are used efficiently and responsibly, through technologies such as renewable energies, efficient lighting and use of recyclable materials (Geissdoerfer et al., 2017) (Stahel, 2016).

This transition is a paramount change in the way the global economy works, having a high impact on the environment, society and the economy. The translation from a linear economy to a circular one can have a significant and positive impact on the environment, society and the economy, by promoting a more effective use of resources and by cutting greenhouse gas emissions and other harmful effects on the environment. (Stahel, 2016). With regard the impact on the environment, the transition to a circular economy can reduce the consumption of natural resources and greenhouse gas emissions, by promoting the sustainable use of resources, recycling and reuse of products. This can contribute to reducing carbon emissions and containing the effects of climate change, reducing pollution and protecting natural habitats.

The impact on society can also be significant, by creating jobs in industry branches such as repair/ maintenance, recycling and remanufacturing, by improving the quality of life and health of the population by means of reducing pollution and increasing the level of education and raising awareness of the population with regard the importance of the circular economy.

Considering the impact on the economy, the circular economy can contribute to increasing productivity and economic effectiveness, by cutting production costs and by increasing competitiveness in the industry. This can also trigger an increase in the number of businesses and a better public image of the companies that adopt sustainable practices.

Therefore we consider that the transition from a linear to a circular economy represents a significant shift in the way we use resources and produce goods and services. By promoting sustainable practices, such as recycling, repairing and reusing products, the circular economy can mitigate the negative impact on the environment, thus contributing to combating climate change and protecting natural habitats.

This transition can also bring social and economic benefits by creating jobs in industry branches such as recycling and repair/ maintenance, improving the quality of life and health of the population, and enhancing the competitiveness and economic productivity through more effective use of resources.

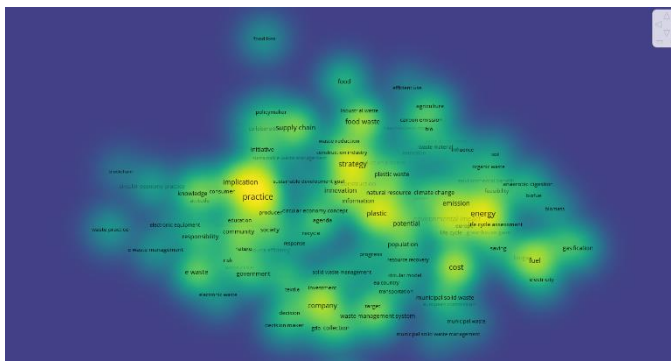


Figure 1. An analysis of the correlations between municipal waste management and circular economy  
Source: the authors

As one can notice in Figure 1 above, the transition to a circular economy requires the involvement and cooperation of the entire society, from companies to consumers and public authorities, as well as significant investments in research and development. Ultimately, the transition to a circular economy can bring significant long-term benefits for the environment, society and economy, and is paramount to secure a sustainable future for our planet.

#### **4. Implementation of some circular economy constituents in the city of Oradea: intelligent waste management**

##### **A. Selective collection of waste**

An important role in achieving a circular economy is also played by an effective management of municipal waste (Ferreira, 2017), especially in view of the selective collection of waste and then in the recycling thereof, since it allows the recycling and reuse of recyclable materials, thus reducing the amount of waste that ends up in the landfill. Effective municipal waste management requires an integrated and multidisciplinary approach that combines different waste treatment options in an optimized way. This approach should include the implementation of waste reduction programs at source, the development of an adequate infrastructure for the selective collection of waste, the promotion of recycling and the use of renewable energy in waste treatment, and the improvement of waste treatment technologies to reduce greenhouse gas emissions and other negative types of impact on the environment. Moreover, in order to reach all the aforementioned objectives, it is necessary to involve all stakeholders, including public authorities, the private sector and civil society, in the management of municipal waste (Munawar, 2021). In the developing countries, multiple challenges raise in terms of municipal waste management, e.g. lack of adequate infrastructure, limited financial resources, as well as lack of public awareness and poor participation of citizens. Thus, it is claimed that the importance objective of addressing the problem of municipal waste management in developing countries should be achieved through an integrated approach and by involving public authorities and the private sector in order to develop more effective and sustainable waste management solutions (Kumar et al., 2019).

Municipal waste management is a major challenge for the cities across the world, and the related problems will worsen in the future as this problem goes hand in hand with the increase in urban population and consumption levels. To prevent this dire perspective to become reality, an integrated and sustainable approach is required, including greater involvement of the private sector and a more holistic approach to waste recovery. We believe that special attention should be given to raising public awareness of the impact of waste on the environment and public health, as well as on the role of local communities in the development and implementation of waste management policies and practices (Hoornweg et. All., 2012).

In the city of Oradea, a selective waste collection system is in place, and this system can be improved by increasing the recycling rate and waste recovery.

## B. Biodegradable waste recycling program

Oradea launched a program for collecting biodegradable waste, which is transformed through an extensive process into compost. This is a classic example of a circular economy, since waste is converted into a useful resource. The sanitation company that carries out the activity of collecting and transporting waste in the city of Oradea has implemented a modern system of selective waste collection through the digitalization of the collection process, which allows the recycling of recyclable materials. Thus, special containers equipped with an RFID chip were introduced on the market in order to identify the economic agent that generated this waste in order to collect recyclable waste, such as paper, plastic, glass and metal. There are also special collection points for hazardous waste and waste electrical and electronic equipment (WEEE). In order to encourage the population to participate in the waste management process, the sanitation company has implemented a charging system based on the volume of waste *generated*. Thus, *families that generate less waste pay less for collection* and transport services, therefore successfully applying the *Pay-as-you-throw* principle.

Implementation of circular economy practices in the city of Oradea has led to some positive outcomes, such as: Increasing the rate of selective waste collection, Thus, in 2021, the rate of selective waste collection in Oradea increased by approximately 30%, compared to the previous year. This is a proof that citizens are more interested in participating in waste management in a more sustainable way; Reducing the amount of waste disposed of in the landfill.

Thanks to the implementation of a modern system of selective waste collection, a significant reduction in the amount of waste reaching the landfill has been achieved. Therefore an extension of the lifetime of the landfill and reduction of related costs is expected.

Through public raising awareness and information campaigns among citizens, a raised public awareness has been achieved. Therefore citizens are prone to adopt a sustainable behaviour and actively participate in waste management in a more responsible way;

BY implementing circular economy practices, a lower impact on the environment has been achieved, by reducing the amount of waste disposed at the landfill and by increasing the recycling rate (Agentia Nationala pentru Protectia Mediului, 2023).

Table 1. Statistical analysis on the amount of waste collected in 2022 in the city of Oradea

Volume m <sup>3</sup>	Valid	12
waste collected	Missing	0
Mean		34885,00
Median		39922,50
Std. Deviation		12013,668
Skewness		-1,789
Std. Error of Skewness		,637
Kurtosis		1,922
Std. Error of Kurtosis		1,232
Minimum		9625
Maximum		44167
Sum		418620

Source: the authors

### C. Statistical data analysis on waste collected in the city of Oradea

According to the statistical analysis we conducted, one can notice that in 2022 a mean amount of 34,885 m<sup>3</sup> of waste was generated every month, the minimum amount reaching 9,625 m<sup>3</sup> in January, while the maximum volume of 44,167 m<sup>3</sup> was recorded in May 2022. However, if we review the median value, we can state that half of the population of the city of Oradea generated an amount between 9,626 m<sup>3</sup> and 39,922.5 m<sup>3</sup>, while the other half generated an amount of waste with volumes ranging between 39,922.50 m<sup>3</sup> and 44,167 m<sup>3</sup>. Overall, in 2022, the municipality of Oradea collected a volume of 418,620 m<sup>3</sup> of waste. We ran the statistical analysis in the dedicated software SPSS 24 (Armonk, NY: IBM). All results are considered significant at a significance level of 0.05, unless the considered level is mentioned.

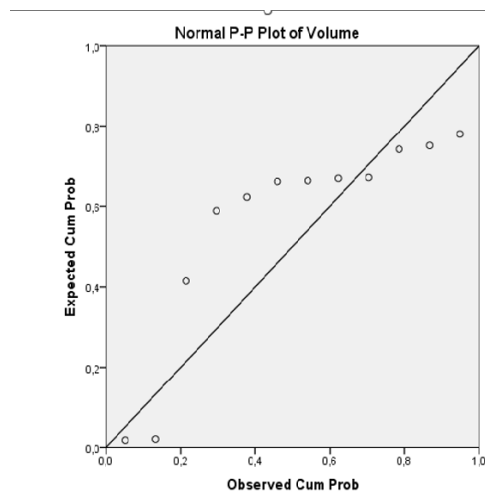


Figure 2. Analysis of the distribution of the amount of waste collected in the city of Oradea by months



throughout a year.  
Source: the authors

With the help of the "Normal P-P" plot, we have tested the assumption of a normal distribution of the volume of waste collected at each month. As one can notice from the chart above, the relationship between the two variables is linear and of medium intensity.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df 1	df 2	Sig. F Change	
1	,635 <sub>a</sub>	,403	,343	9736,607	,403	6,747	1	10	,027	,564

a. Predictors: (Constant), Month

b. Dependent Variable: Volume

Table 2. Analysis of the link between the amount of waste and the month in which it was collected  
Source: the authors

The statistical model is significant, with a p-value<0.05. R-square suggests a medium intensity relationship among waste change over time. The Durbin-Watson statistic indicates the presence of autocorrelation in the change of waste over time, a value below 2 suggesting a positive autocorrelation.

In general, one can notice a positive evolution of waste management in Oradea, which has as main objective the adoption of circular economy practices and a more responsible and sustainable waste management.

## 5. Conclusions

The transition from the linear to the circular economy is an easily observable reality in all developed countries. The European Union, through the programs targeting specially this matter, manages to deliver the best results and continues to remain a model for the whole world. If from a conceptual point of view, things are broadly well clarified and at the same time accepted by all global stakeholders, in terms of the implementing these measures, certain gaps can be observed, but also different paces of implementation. Romania as an EU Members State has undertaken a firm timetable regarding the implementation of all such measures. The city of Oradea is always remembered as a positive example of how it manages to implement the newest and most effective technologies. Through this work we show not only how

the circular economy will inevitably take the place of the linear economy by mentioning in that regard the most important works from the dedicated literature, but we also give concrete example of how the implementation of the circular economy principles in waste management in the city of Oradea validates all the principles mentioned in the theoretical part of the paper.

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