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The Relationship Between the Circular Economy and Sustainable Waste Management in European Union

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ABSTRACT

Modern life has contributed both to increasing living standards, increasing comfort and the development of society, but also to increasing the amount of waste that suffocates the planet and threatens the existence of present and future generations. Among the solutions that are sought and that are included in various programs and policies, the concept of circular economy is one that is increasingly discussed when talking about the sustainable development of society. The circular economy implies a reduction of the natural resources consumed due to both recycling and their fair consumption. At the U.E. level the foundations have been laid for policies aimed at waste management to ensure the application of the principles of the circular economy.

Considering the importance that the quantification of the indicators for implementing the circular economy have on the elaboration of more efficient policies, but also on the determination of the degree of implementation of this concept, in this paper we intend to analyze the evolution of these indicators from 2010-2019, in the European Union using a customized version of the DPSIR model. Their analysis led us to the conclusion that although important steps have been taken towards the transition to the circular economy, there are still many aspects that need to be improved in order to achieve the proposed objectives through European policies.

1. Introduction

The emergence of modern society characterized by an increase in population and an increase in urbanization, the technology development of information and communications, income growth accompanied by increasing living standards, reducing the life cycle of products as a result of transforming the society into a society of consumption were accompanied by the increase in the volume of waste produced, but also by their diversification and the flows

they generate, all this taking place on the sharp reduction of natural resources and the increase of pollution. That is why the concerns of existing decision-makers at international level regarding waste management have intensified from the need to identify sustainable economic and social development solutions, which involve both the management of raw materials and by-products, waste, energy consumed, etc., so as to ensure the conservation of limited resources and the protection of the environment. In this

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context, an essential condition of the socio-economic evolution of the society is represented by the way of waste management.

The effects of the circular economy would also mean an improvement in the quality of life and an improvement in human health^[6], or health and well-being are important elements of economic and social development, and are found in the general objectives of European policies along with those on sustainable models consumption, ecologies have environmental protection^[5].

The European Parliament adopted in 2015 an action plan, containing 54 measures, in order to accelerate the transition to the circular economy, through which it was intended to stimulate global competitiveness and promote sustainable economic growth and create new jobs the work.

The Communication “Closing the Loop - An E.U. Action Plan for the Circular Economy” - (COM (2015) includes for the first time the definition of the circular economy, which was conceived as a model of production and consumption involving both sharing and reuse of materials; products, their repair or renovation, as well as their recycling. This way the “closing of the loop”, ie the circularity, is a concept that has been proposed since 1977 by Stahei and Reday - Mulvey in a report entitled “The potential of to replace human labor for energy” and which supported the idea of creating new jobs, reducing waste and increasing economic competitiveness^[7].

Thus, at the E.U. level, through these policies were established criteria for implementing the principles of the circular economy at the level of member countries, which proposed: reducing the amount of household waste stored; increasing the amount of household waste to be reused or recycled and prohibiting the storage of waste.

The Ellen MacArthur Foundation is also the one that paved the way for the circular economy. Thus, the study on the circular economy shows that this is an economy that is restorative and regenerative by design and aims to keep products, components and materials at their highest utility and value at all times, being inspired by nature, where nothing is lost everything changes^[9].

These approaches to European policies have continued. Thus in 2018 through the Action Plan on the circular economy - (COM (2018) 32) were set as objectives: the use of recycling, increasing the use of secondary raw materials, replacing chemicals of concern and reducing their use in order to improve their traceability.

Also in 2018 another European strategy for plastics in a circular economy - (COM (2018) 28) aims to recycle all plastic packaging by 2030, thus ensuring the transition to a more circular economy.

Through Directive (EU) 2018/851 amending Directive 2008/98/EC on waste, EU Member States they were invited to take the necessary measures to reduce food waste related to supply chains, to monitor the quantities of food waste, but also to report on progress.

The EU’s approach to the circular economy involves promoting resource efficiency, but also reducing the impact on the environment by reusing products, materials or resources so that waste generation is minimal and pollution is reduced. At the same time the E.U. promotes ethical and fair trade, as well as the most sustainable management of supply chains. Actions taken can also stimulate investment, create a level playing field and remove barriers to the single market.

The circular economy does not only follow the economic or environmental aspects, but also the social and governance aspects. However, its essence is to ensure the recycling and reuse of materials and products, also analyzing gas emissions with a role in environmental degradation^[3].

2. Material and Methods

The research methodology involved the study of literature in order to define the circular economy and identify the indicators based on which it can be quantified (1), research international databases that provide information to calculate indicators (2), calculation, analysis and interpretation indicators (3) and the formulation of conclusions regarding the study (4).

The analysis followed the progress made in the E.U. on waste management, following both economic and social and environmental aspects, using a customized version of the DPSIR model belonging to the European Environment Agency, which in its turn is an extended version of the “Pressure-State-Response” model. “Created by the OECD and which allows the creation of a vision regarding the decision-making context related to one or more sectors of activity.”

The DPSIR model (Driving forces, Pressures, States, Impact and Responses) was proposed by the European Environment Agency in 1999, in order to identify the main indicators underlying the understanding of the complex links between economic, social and environmental systems thus the possibility of performing an integrated analysis of environmental protection activities. It was also used by the United Nations and subsequently adopted by the US Environmental Protection Agency (EPA). Its use has been made in various fields such as the management of agricultural systems, the management of soil resources, water resources, marine resources, but its most frequent use is related to environmental protection. EPA has added

to the existing elements other explicit issues related to human health by adding the health of ecosystems, and also issues related to sustainability^[1].

Each of the five domains (Driving forces, Pressures, State, Impact and Responses) contains sub-domains to which specific indicators are attributed, which underlie the decision-making process and which substantiate a systemic and dynamic vision of it.

The model thus captures the existing interactions between its components establishing the causal relationships between them, and which can be weak links, strong qualitative links or strong quantitative links. Establishing a balance between components allows a transition to the circular economy.

In the study of the transition to the circular economy, the DPSIR model includes: D - the development needs of individuals, of society, which promotes a certain model of production and consumption; P- effects on the environment; The current state of the various components of the environment; I- the changes occurred in the change of the current state of the environment and which affect the welfare at social level; R- response of the company or decision makers on the impact^[4,11]. This approach has been used in the analysis of environmental issues, both globally and zonally^[2].

The model has been used in other studies which show that the relationship between driving forces (D) - pressures (P) brings to the fore the role of efficient technologies and the process of innovation to meet the challenges / present state (S), the impact (I) and the need to identify the most appropriate type of response (R) ”^[8].

On one hand, the analysis of the relationships used by the DPSIR model presents the relationship of three elements: Motor forces (D) - Pressures (P) - Response (R), which provide an image of their causal links, and on the other hand achieved by the relationship between State (S) - Impact (I) - Response (R).

The model proposed by *Tartiu et al., 2018*, considers that the relationship between driving forces (D) - pressures (P) emphasizes the role that the use of efficient technologies and innovation have in relation to current challenges (S), as well as impact (I) and the need finding an effective response (R).

3. Results and Discussions

Through this study we aimed to analyze the correlations between the circular economy and sustainable development.

The analysis carried out through the DPSIR model follows the level of implementation of the circular economy principles at the European Union level as modalities for

achieving the objectives of sustainable development, considering that the indicators that characterize the circular economy are also indicators of sustainable development, economic, social, environmental objectives, following the management of consumed resources and the resulting waste.

The driving forces used in the model to promote the circular economy were represented by the evolution of GDP relative to greenhouse gas emissions.

For the pressure analysis, the indicators followed were: the evolution of the population, both for the total population of the European Union, and for the population of the ones over 64 years. GHG emissions analyzed in relation to the evolution of GDP are an indicator for measuring pressures.

The common Elements of Response are represented by the implementation of legislation in the field of environmental protection, policies applied to increase efficiency in the use of resources, raising awareness of the population on the need to move to the circular economy. The indicator used was the recycling rate for different categories of waste, analyzed comparatively from 2010-2019.

The proposed indicators for Status (S) are: direct material inputs (KAI), material dependence (DE), imports, and for Impact (I): competitiveness index.

The economic development analyzed from the perspective of the circular economy must follow both the economic impact (GDP growth, share of investments, etc.), the impact on the environment (use of resources, reduction of greenhouse gas emissions, reduction of pollution) and social impact (changes demographics, education, quality of life, social inequities, etc.)

Waste is an important problem for the environment, but at the same time it is an economic loss for society. At the level of 2018, Europeans produced an average quantity of 5.19 tons/capita, of which the amount of municipal waste was 492 kg/capita. Although a large amount of waste is recycled, another part is turned into compost, there is a smaller part that is stored. That is why we need to change both the way we produce and the way we consume, in order to produce a smaller amount of waste, but also using it as a resource that can lead to saving depletable resources.

Proposing to analyze the indicators presented above, we found that at the EU-28 level the GDP growth rate had an oscillating evolution, with the highest value recorded in 2018 (USD 15,962 trillion). The declines in 2015 and 2016 were due to the effects of the economic crisis that began in 2007 and whose shocks continued to be felt in the following years. A revival of the economic situation began to be felt only towards the end of 2016 when both the world economy and that of the E.U. recorded a modest

recovery, continuing to grow until 2019, whose end of the year was again affected by the shocks of the Covid-19 crisis.

Regarding the CO2 emissions per capita, there is a decrease per capita in the analyzed period as a result of the transition to the production of alternative energy and the decrease of the share represented by the energy produced from fossil fuel sources. At the same time, at the E.U. level the European scheme for greenhouse gas emissions trading has been implemented, which has had the effect of reducing these emissions (EU ETS).

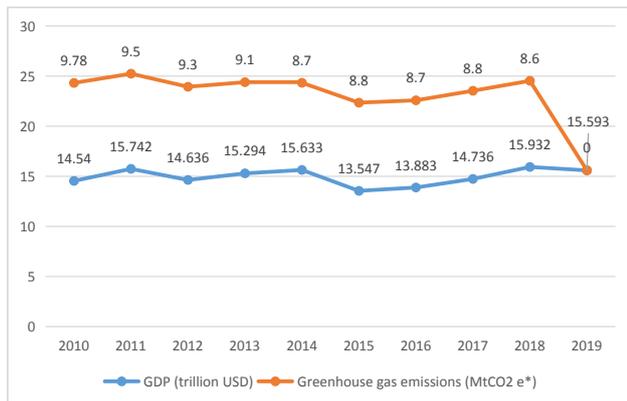


Figure 1. Evolution of GDP relative to greenhouse gas emissions

Source: own processing^[10]

These indicators must be correlated with the evolution of the population at the E.U. level. - 28. Where demographic changes affect the amount of waste generated. Thus, the increase in the number of households made up of a single person or a small number of members can have influences on the amount of waste^[12]. Thus, based on the data published on January 1, we find a continuous increase of the population during the analyzed period, although this was not significant. The increase from 2010 to 2019 was 2%.

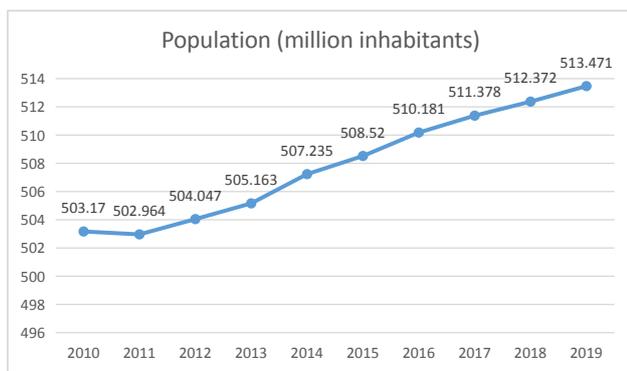


Figure 2. The evolution of the E.U. population

Source: own processing^[10]

Another aspect that should be correlated with the

evolution of the E.U. population. is the percentage represented by people over 65 years of age, which shows that life expectancy increased by 14% in the analyzed period, but this does not greatly influence current consumption patterns, the degree of adoption to them by the population more in age being much younger. As the population grows, the amount of raw material processed also increases, which causes an increase in the amount of waste.

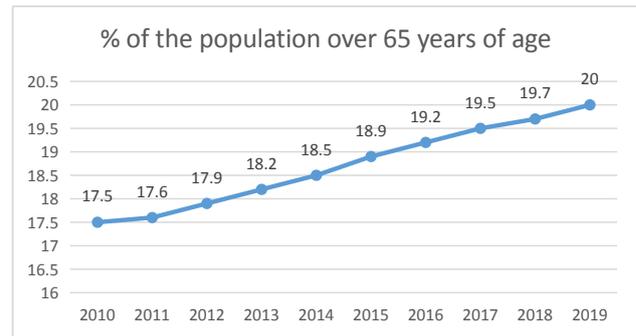


Figure 3. Evolution of the population over 65 years of age (% of total population)

Source: own processing^[10]

The intensity of primary energy is the indicator expresses the productivity of resources or energy used. It is determined in relation to the value of GDP and can be expressed in toe / 1000 Euro or in toe / 1000 Euro PPC, ie in euros at purchasing power parity. Primary energy consumption is an important indicator in monitoring the progress that the E.U. made them to achieve the targets that are set by European directives, being defined as the difference calculated between gross primary energy consumption and non-energy consumption of energy carriers (natural gas, oil, etc.).

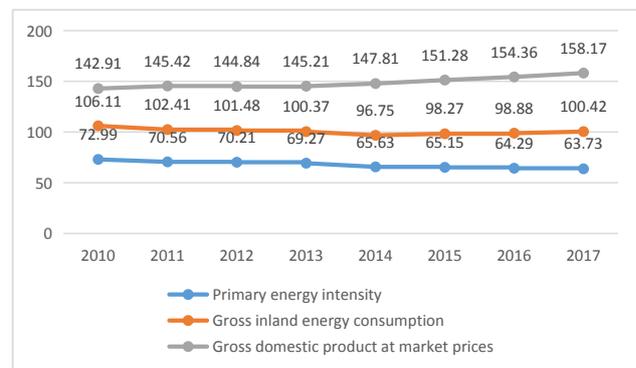


Figure 4. Evolution of primary energy intensity

Source: own processing^[10]

Eurostat data on the primary energy intensity show that its value decreased during the period under review, given that there was an increase in GDP in the E.U. - 28. The decrease from 2017 compared to 2010 was 13%.

There is also an increase in gross domestic energy

consumption within the E.U., but at a slower pace than economic growth. While from 2010 to 2014 the decrease in gross energy consumption was about 0.8% per year, GDP growth was about 1.2% per year. In 2016 and 2017, gross energy consumption increased by 1.6%, and GDP increased by 2.5%. In 2017, the average primary energy intensity for the 28 member states of the European Union was 3.3 toe / capita.

This is due to the increase in energy efficiency, on the one hand in the final consumption sectors where energy efficiency programs have been adopted, and on the other hand due to the reduction of the amount of primary energy required to produce a final energy unit. The primary energy intensity indicator is a macroeconomic parameter whose values depend on the structure of the economy, but which can also characterize energy efficiency.

Schimbările structurale care au avut loc în economie au inclus și o creștere a contribuției pe care serviciile au avut-o în formarea PIB, precum și o trecere la industrii care sunt mai puțin consumatoare de energie, dar care au o valoare adăugată mai mare. Productivitatea utilizării resurselor se determină prin raportul dintre consumul material și PIB.

The optimization of resource consumption is also achieved by implementing legislation on waste management that must be as efficient as possible. In this sense, the comparative analysis of the way in which the recycling rates for the main types of waste evolved in the period 2010-2019.

The way waste is managed is closely linked to existing legislation at the EU level. The main legislative instrument is the Waste Framework Directive which aims to prevent the production of waste, but to use it as a resource, and then to reduce the amount of waste stored. Thus, a hierarchy of the waste management model is presented, starting primarily from the prevention of waste, the ways of preparing them for reuse, recycling or recovery, as well as the ways of disposing of them. The directive also sets specific targets for each EU country. Thus, by the end of 2020, the recycling rate set for municipal waste was set at 50%, the recycling rate for paper was set at 74%, and the recycling rate for non-hazardous construction and demolition waste was set at 70%.

The waste collection process is a sensitive point in their management. Collection rates vary depending on the level of income, finding that high- and middle-income countries ensure almost universal waste collection, while in low-income countries the collection rate is about 48% in urban areas and about 26% in rural areas. Also, the level of income influences the composition of waste, finding that in high-income countries there is a lower amount of green

waste and food waste and a higher amount of dry waste that can be recycled.

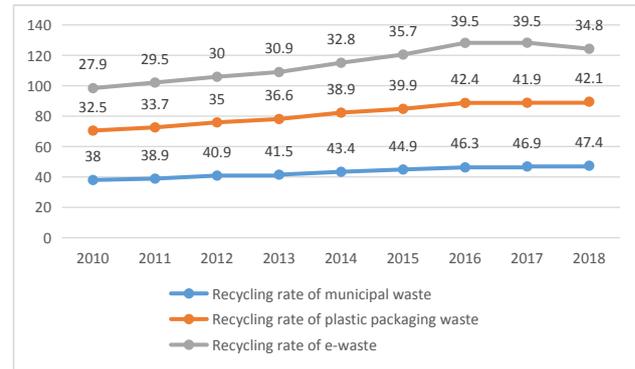


Figure 5. Evolution of recycling rates for different categories of waste

Source: own processing^[10]

It is found that recycling rates are increasing during the analyzed period. The recycling of plastic packaging waste registered a rate of 42.1% in 2018, which represents an increase of 30% compared to 2010, and the recycling rates of household waste and e-waste increased by 25% in the same period.

The highest recycling rate is construction and demolition waste, which reaches up to 34% of total waste in the EU. They are characterized by a high recovery rate, but need even more efficient management to strengthen the circular economy of the EU. More and more efficiently the exchange of information on the reuse of secondary raw materials can contribute to the implementation of actions that have been inspired by the circular economy. However, despite the large amounts of construction waste, it is found that past construction practices make the resulting material flows unsuitable for closing the loop in this sector, thus preventing the full application of the objectives of the circular economy.

On the other hand, the circular economy uses resources that can be represented by waste that makes it possible to close the loop, representing at the same time an important source of productivity growth. Therefore, we will further analyze the indicators related to Status (S), Impact (I) and Response (R).

The common indicators for the selected Status and Impact were: direct material inputs, material dependence, imports and competitiveness index^[8]. The direct inflows of materials reflect the level of development from a technological point of view, in direct connection with the quantities of natural resources in the form of reserves, but also in relation to the intensity of foreign trade. Material dependence reflects the economy's dependence on the amount of domestic natural resources.

A key priority is to measure resource efficiency as well as waste reduction by tracking material flows.

Monitoring the efficient use of resources is important both in terms of increasing the amount of recycling materials, and in terms of increasing the share of secondary resources used or reducing waste streams, with an impact on the environment.

The material flows that are reflected by the above indicators, and that use as a unit of measurement billion tons / year, show the recirculation rates of starting with 2014, the year before the European Directive, compared to 2017 and 2018. It is thus found a increase in the rate of circularity of material use which in 2018 was 11.9% and which was due on the one hand to the increase in the amount of materials used and processed, which also contributed to an increase in total emissions, and on the other hand to a direct decrease exploited materials and natural resources extracted. It is also found that in order to ensure the flow of material necessary for processing, there were both increases in the value of imports at the EU level, but also increases in exports. The rate of circularity of material use was 11.2% in 2012 and 11.4% in 2016. However, estimates of the amount of material processed, gas emissions or population growth are not encouraging.

Thus, it is estimated that in 2060, worldwide the amount of used material will reach 167 Gt, increasing by 111% compared to 2010, materials use / capita / day will reach 45 kg in 2060, compared to 33 kg in 2010, and greenhouse gas emission from materials extraction and processing will reach 21%. However, material intensity will decrease in 2017-2060 by 1.3%^[13].

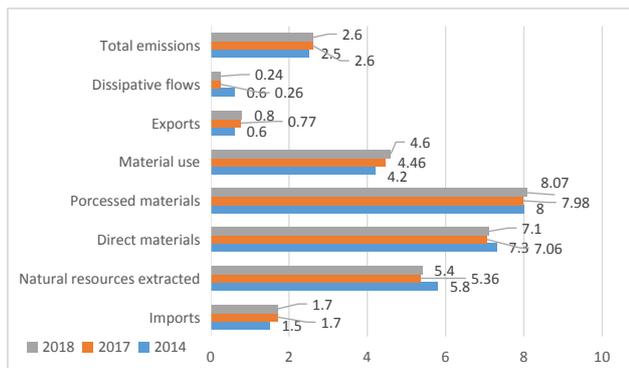


Figure 6. Comparative analysis of material flows

Source: own processing^[10]

Equally important is the aspect of public awareness about the importance of natural resources for the future of the planet and the optimization of resource use in the circular economy.

Next we will analyze the economic resources that have been allocated by the general economy for those activities

and actions of prevention, reduction, but also elimination of pollution or environmental degradation. EPE is divided into current expenses and investments. The mandatory and standardized system included in 2017 on EPEA has improved and will continue to improve the reporting system.

The costs of environmental protection, ie pollution reduction, biodiversity protection, wastewater management, as well as waste, research and development or education and training are an important component in supporting the circular economy.

The role of the analysis of environmental protection expenditures is to evaluate environmental policies. Expenditure information highlights cleaning costs and less cost reductions that are the result of reduced greenhouse gas emissions or high environmental protection measures.

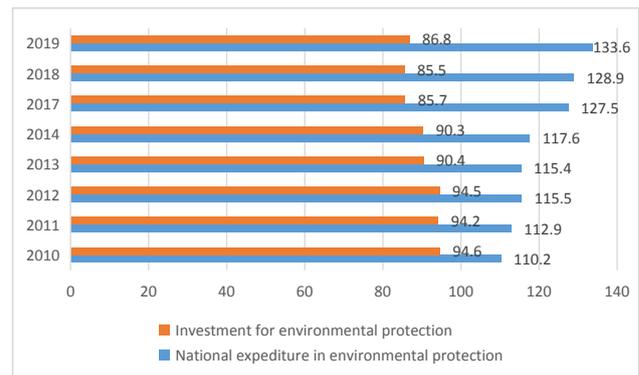


Figure 7. Evolution of environmental protection expenditures and other investments in environmental protection

Source: own processing^[10]

Data taken from Eurostat data show that environmental protection spending in the E.U. increased during the analyzed period. Thus, at the level of 2019, the value of 133.60 million Euros, increasing by 21% compared to 2010. This takes place against the background of the trend of transferring the taxation method, ie the transition from the taxation of human capital to the taxation of resource consumption. In terms of investments for environmental protection, they decreased by 8% in 2019 compared to 2010.

The European strategy on the bioeconomy, which was renewed in 2018, aimed at both modernizing and consolidating the industrial base at E.U. level through new value chains, but also more cost-efficient industrial processes.

At the E.U. level there are many policies aimed at a circular economy represented by the Action Plan for the economy, environmental policies, climate policies, energy policies, etc. The main objectives are to create strong synergies between elements in order to increase the benefits within the Union, but also the capacity to exploit the op-

portunities of the circular economy.

Recent initiatives include the “Circular Economy Action Plan for a Cleaner and More Competitive Europe”, which was published on 11 March 2020 and includes measures to reduce waste from newer sectors (electronics, textiles, construction, as well as the inclusion of new objectives aimed at reducing waste, but also the adoption of ways to manage and recycle waste in the long term.

Compared to previous E.U. legislation addressing product sustainability, the new legislative initiative gives consumers the “right to repair” electronic products.

The European Commission is also proposing to create a common database for “smart circular applications” to provide consumers with information on products and value chains.

Consumer legislation will also be reviewed so that they can be provided with reliable information on the life of products, maintenance services and spare parts, so that companies must comply with these minimum sustainability labeling requirements, for information, and for ICT and electronics, it is mandatory to provide modernization services.

Another aspect concerns the adoption of additional sustainability requirements for products arriving on the E.U. market and coming from other countries.

Following the adoption of these legislative as well as non-legislative measures on the circular economy, in 2021 the European Commission will develop additional indicators on resource efficiency, consumption and material footprint.

4. Conclusions

Circular economy is an alternative to the linear economic model based on the theory of using natural resources available for a long time, easy to exploit and whose elimination does not involve high costs. Given that the world is facing planetary limits, there is a need to implement a new model, that of the circular economy which aims to maintain the usefulness of goods and products for as long as possible, while maintaining its value, which reduces the pressure on the environment.

In this context, waste management is an important part of the circular economy, which involves an in-depth analysis of the entire value chain of products, starting with their extraction, ecological design and obtaining finished products that are a new resource used in another section. At the same time, the concept of circular economy is closely linked to increasing competitiveness, and ensuring optimal use of resources involves the use of models that promote their sustainable use.

The role of the DPSIR model was to analyze the flow

of factors that must be followed when making legislative decisions regarding waste management, but also on the other elements that characterize the circular economy. The relations established between the component elements offer a dynamic approach regarding the public policies in the field of waste and recycling and their reuse in the attempt to respect the principles of the circular economy and the green economy.

Against the background of population growth, resource consumption will increase, but we can move to a reduction in consumption intensity as a result of taking measures to protect natural resources. Thus, recycling becomes a more competitive way of using materials than the exploitation of natural resources as a result of the development of technology, but also due to more competitive prices.

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