

The circular economy as a tool for achieving environmental sustainability

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Abstract. Human well-being is closely related to the health and sustainability of the environment. People need clean air to breathe, fresh water to drink, and places to live free of toxic substances and hazards. There are many problems that hinder environmental sustainability, including environmental pollution from industrial production, carbon emissions and waste; inappropriate waste management; economic interests and disclaimers by companies and governments and individual behaviour and consumer habits. All these problems require systemic solutions and global coordination between governments, businesses and the public to ensure environmental sustainability and the preservation of natural resources for future generations. The publication analyses the concept of environmental sustainability and the circular economy as an approach to achieving it, as well as the relationship between increasing carbon dioxide emissions and the number of world populations.

1 Sustainable development character

In a traditional linear economy, resources are extracted, processed, used and then discarded as waste. In a circular economy, however, this process is done so that waste and resources are returned to the system to be reused. The publication examines the benefits of the circular economy for environmental sustainability, aiming to reveal the concept as a potential tool for achieving environmental sustainability.

For more than two millennia, humanity has contributed to global climate change. According to the Intergovernmental Panel on Climate Change (IPCC), the United Nations organization for assessing climate change, it is human actions that have affected the planet, leading to warming of the atmosphere, oceans and land. [1]

Sustainability or sustainable development is characterized as meeting the needs of present generations without compromising the ability of future generations to meet their own needs. [2]

For businesses, social sustainability includes important workplace and employee issues such as health and safety, inclusion, empowerment, professional development opportunities and work-life balance; [3]

Widok [4] draws on multiple conceptual frameworks from the academic literature and defines it as “protecting, promoting and preserving transparency, justice, balance, equality,

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well-being, health and safety for future generations, including people, their rights and the preservation of biodiversity".

Economic sustainability is focused on the ability of an organization to remain profitable throughout its life, economic sustainability is not just based on finances. An economically sustainable organization is one that can drive revenue and sustain long-term business growth without negatively affecting the community, the environment, or the health and well-being of its employees.

Environmental sustainability aims to protect the environment for future generations. [5] Environmentally sustainable organizations take steps to increase efficiency, reduce resource consumption and waste, and measure and track carbon emissions throughout the supply chain. Today, many organizations are stepping up their environmental efforts by adopting sophisticated technologies, including cloud and IoT sustainability solutions that allow them to track and reduce their environmental impact.

2 Environmental sustainability

The negative impacts caused by climate change are encouraging an increasing number of governments, organizations and individuals to adopt and contribute to environmental sustainability. These various groups are working to achieve full decarbonization to protect global ecosystems for the sake of future generations. [6]

Environmental sustainability refers to the ability of a system, community or organization to exist and function in harmony with nature, preserving resources and ecosystems for future generations. This means using natural resources in a way that is sustainable and does not exceed the planet's ability to reproduce or restore them.

The current challenges of resource depletion and environmental pollution are mainly the result of unsustainable economic models and adverse environmental impacts. The challenges underlying environmental sustainability can be divided into several groups:

- Resource depletion: The use of unsustainable practices in the extraction and use of natural resources such as fuels, minerals and water leads to their depletion. If alternative sources are not found or consumption and waste are not reduced, resources will be limited, which can have serious economic and social consequences. [7]

- Environmental pollution: Industrial processes, fuel emissions, unsustainable agriculture and waste that seriously pollute air, water and soil. All this has a negative effect on biodiversity, human health and ecosystems.

- Climate change: Greenhouse gases, primarily carbon dioxide, from human activities contribute to climate change. This leads to an increase in the temperatures of the earth's surfaces, a change in climate patterns and an increase in the frequency of extreme weather events such as heat, floods and drought. Climate change has serious consequences for animals, plants, ecosystems and people, as well as for the economy and society as a whole. [8]

- Loss of biodiversity: The uncontrolled destruction of natural environments and ecosystems, the introduction of invasive species and the use of pesticides and herbicides have a negative impact on biodiversity. Loss of species and ecosystem diversity can disrupt the balance and functioning of natural systems. [7]

- Population and sustainability: The rapid growth of the world's population is putting great pressure on natural resources and the environment. Meeting the basic needs of a growing population, such as food, water, energy and housing, requires sustainable approaches and innovation.

To solve all these challenges, it is necessary to promote sustainable practices and technologies that reduce the burden on the environment and conserve resources. This includes transitioning to renewable energy sources, efficient use of resources, recycling and

waste management, protecting ecosystems and biodiversity, and promoting sustainable agriculture and urban planning. In addition, global cooperation, political commitment and awareness on the part of people, society, business and governments are needed to achieve environmental sustainability and preserve our planet for future generations.

3 Circular economy knowledge for sustainability challenges

A circular economy is a concept that is based on the idea of utilizing resources and materials as efficiently as possible, minimizing waste and promoting renewability. It seeks to create a closed cycle of production, consumption and waste, where materials and resources are recycled and reused instead of being thrown away after their use. [9]

The traditional linear model of economic growth focuses on the production and consumption of goods, as resources are depleted and a large amount of waste is generated. This creates a burden on the environment and leads to unsustainable use of resources. This model is often aimed at economic growth and encouraging consumption as the engine of the economy. [10]

In stark contrast, the circular economy moves to an innovative approach that is based on the three main principles: reduction of sources and materials, recycling and recovery, and regeneration of natural resources. Instead of being discarded after use, products and materials are converted and reused in the economic system. This can be achieved through recycling, repair and resource sharing. [11]

The circular economy has the potential to create a more sustainable and resource-efficient economy. It can lead to a reduction in the load on the environment and a reduction in waste. At the same time, the circular economy can create new opportunities for business and economic growth through the development of innovative technologies, services and business models. This may include developing new recycling and recovery methods, expanding the sharing economy, and developing products and services that are designed to be sustainable and easily recyclable.

Connecting the circular economy to existing models of economic growth can be challenging as it requires changes in the views and practices of businesses, consumers and governments. Innovations are needed in product design, production processes and waste management systems. Furthermore, the creation of appropriate legislative frameworks, economic incentives and educational programs can be essential for the successful implementation of the circular economy.

Ultimately, the circular economy has the potential to provide sustainable and sustainable development where economic growth is in sync with environmental protection and resource conservation for future generations. It can create benefits both for the environment and for the economy and society as a whole by promoting innovation, creating jobs and improving the quality of life.

4 From circular economy to environmental sustainability

The circular economy promotes the use of resources in a way that maximizes their value and duration. This includes the optimization of production processes, the use of energy and water with less waste, as well as the prevention of losses during production chains and contributes to reducing the burden on the environment and the optimal use of limited resources.

Instead of being thrown away after use, materials are converted and recycled to be used again in the economic system. This includes separation and sorting of waste, recycling of materials and recovery of useful ingredients. The principle of recycling is applied at both industrial and consumer levels and reduces the pressure on ecosystems, reduces pollution and

energy expenditure associated with the extraction of raw materials and helps to preserve natural resources.

Instead of designing and manufacturing products that have a short life cycle or wear out quickly, the circular economy encourages the development of products with a longer life. This includes choosing quality materials and components that can be maintained, repaired and upgraded to continue to function and have value for longer. These approaches reduce the need for constant production of new products and the resource-intensive processes associated with them and contribute to reducing waste and energy consumption.

Closed-loop design - this approach refers to the design of products and services with the possibility of recycling and recovery of materials after the end of their life cycle. This includes the use of materials that are easily disassembled and recyclable, as well as the implementation of waste collection and recycling systems. Products are designed so that at the end of their life cycle they can be dismantled and their materials can be used to make new products.

Stimulating innovation and creating new business opportunities. The principles of the circular economy require a rethinking of business models and production processes. This opens doors for the development of innovative technologies, products and services that are aimed at environmental sustainability.

All these principles of the circular economy create the possibility of a closed loop of materials and resources, where nothing is thrown away or wasted. Instead, resources are used efficiently and reused, reducing the need for new raw materials and reducing the burden on the environment. [12]

Some of the principles of the circular economy emerged hundreds of years before the debate on sustainable development arose. [13]

The circular economy has the potential to change the way the economic system works by creating a sustainable and sustainable alternative to traditional models of economic growth. It promotes innovation in production processes, business models and consumer habits, creating opportunities for the creation of new jobs and economic growth, combined with environmental protection and optimal use of resources. It paves the way to a more sustainable, responsible and environmentally conscious economy that combines thriving business with nature conservation and societal well-being.

5 Circular business models

Applying circular business models can bring many benefits and have a significant positive effect on the environment. [14] The main potential benefits are focused on:

- Reduction of waste by promoting its transformation into resources. Instead of being thrown away, materials are recycled and recovered, reducing the amount of waste that ends up in landfills or the environment. This reduces the pressure on landfills and helps to optimize the use of materials.
- Reducing the consumption of raw materials, through their reuse and recovery of materials. This helps prevent excessive depletion of natural resources and reduces the environmental impact associated with the extraction and production of raw materials.
- Reduction of energy and water consumption through efficient use of resources. The processes of recycling, recovery and resource sharing enable more efficient use of energy and water, which reduces consumption and the associated emissions of greenhouse gases and other pollutants.
- Reduction of greenhouse gas emissions through sustainable practices. [14]
- Improving the quality of the environment by reducing waste, greenhouse gas emissions and resource consumption contributes to reducing water, air and soil pollution. This results in a cleaner and healthier environment for animals, plants and people.

- Creation of green jobs. Recycling, recovery of materials, development of energy-efficient technologies and other sustainable practices create a need for specialists and workers in these fields. This not only supports economic growth, but also promotes a shift towards more sustainable and innovative economic models. [15]
- Improving public welfare by protecting resources and the environment. By reducing pollution and stress on ecosystems, better health and quality of life is ensured. Furthermore, the introduction of sustainable business models and social innovation can contribute to social justice and the development of sustainable communities.

6 Challenges and limitations to the circular economy

The transition to a circular economy faces a number of challenges and limitations. One of the major challenges is the availability of appropriate infrastructure and technologies for the collection, sorting, recycling and recovery of materials. Investments are required to build the appropriate infrastructure, which can quickly become expensive and time-consuming. Introducing a circular economy requires reorganization and collaboration throughout the supply chain. Systems for the collection, recycling and recovery of materials must be established to cover all steps of the production process, from raw material to finished product. Despite the potential for economic growth and job creation, the transition to a circular economy may require significant investment and change in business models. Some businesses may face limitations in existing processes and profit models. The successful introduction of a circular economy requires awareness and participation on the part of society. Public awareness and education are essential to encourage consumers to adopt and support sustainable products and services. Material flows and supply chains are often complex and multifaceted, which can complicate the realization of a circular economy. Changing consumer behavior is essential for the successful implementation of the circular economy. Consumers should be encouraged to choose products that are more sustainable and easily recyclable. However, this can be challenging as consumers are often driven by low price and short-term gratification. Strong legal frameworks and incentives are needed to promote the transition to a circular economy. The lack of clear and effective rules and regulations can make the transition difficult. Appropriate economic instruments, such as tax breaks or subsidies, are needed to encourage companies to invest in sustainable practices. The global nature of many businesses can complicate the implementation of circular models. The global supply chain often involves different countries with different legal and regulatory frameworks, which can make it difficult to establish common standards and cooperation.

Despite the described challenges, the circular economy has great potential to contribute to ecological sustainability and environmental protection. Collaboration between government, business and society is needed to overcome these challenges and promote the implementation of circular business models and practices.

7 Researches

An author's study was carried out, which traces the development of the circular economy. Statistical methods were used for data processing.

The circular material use rate in the EU for the period 2004-2020 has been analyzed, and the analysis confirms the growth of the share of the circular economy within the EU for the studied period. Fig. 1 presents the use of circular materials within the EU for the period 2004 to 2020, as well as its estimated growth until 2025. The forecast is made in a 95% confidence interval.

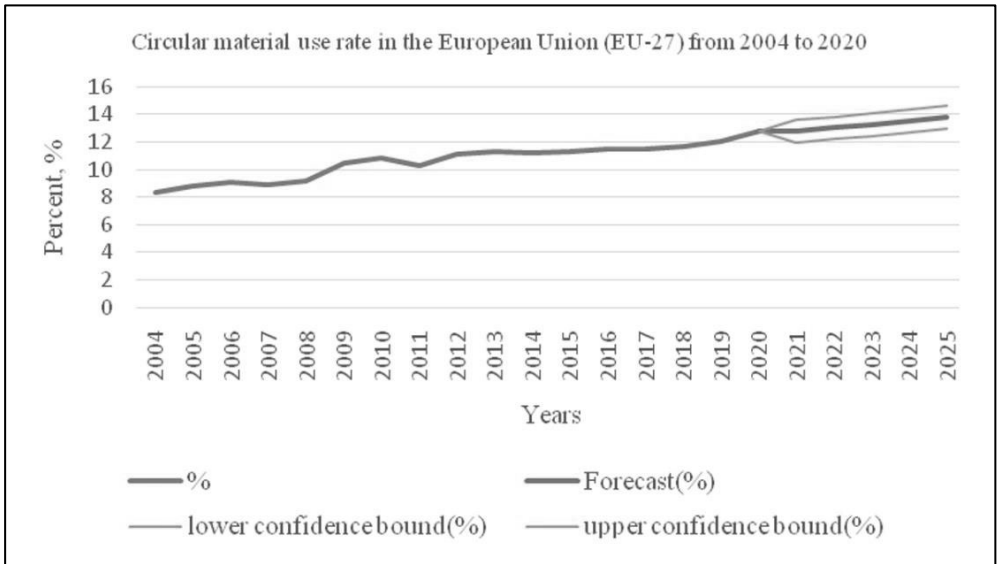


Fig. 1. Circular material use rate in the European Union (EU-27) from 2004 to 2020.

The analysis of the growth of the circular economy in the European Union (EU) shows positive trends and efforts to change towards more sustainable models of production and consumption. The EU actively promotes and supports the principles of the circular economy, which is reflected at various levels - from political strategies to specific initiatives and programs.

Among the EU's key circular economy initiatives is the Circular Economy Package approved in December 2015. This package consists of a number of legislative proposals and measures aimed at promoting recycling, reducing waste and efficient use of resources in various sectors, including industry, the food chain and the waste sector. In addition, the EU promotes the transition to a circular economy through financial instruments such as the European Fund for Strategic Investments and the Horizon 2020 programme. These instruments provide funding and support for innovative projects and business models that focus on the sustainable use of resources and environmental protection. At the national level, many EU Member States are adopting their own circular economy strategies and plans. They create a regulatory framework, encourage innovation and help businesses implement sustainable practices. Some countries, such as the Netherlands and Denmark, have shown more advanced progress in introducing a circular economy and are considered leaders in this field.

The publication also examines the development of carbon emissions, the importance of which for sustainable development and the fight against climate change is essential. It is believed that the emergence of circular business models will help reduce the amount of carbon emissions in the long term. However, the total number of the population also affects the amount of carbon emissions. It turns out that there is a very strong, almost functional relationship between pollution and population (the correlation coefficient is $r=0.994$). The dependence is presented graphically in fig. 2. The equation describing the dependence and the coefficient of determination $R^2=0.9889$ are also shown. Based on this model, it can be predicted what the pollution will be like in 2050, when the population of the earth is expected to be 9735 million. The forecast shows that carbon emissions can be expected to be 519.6388.

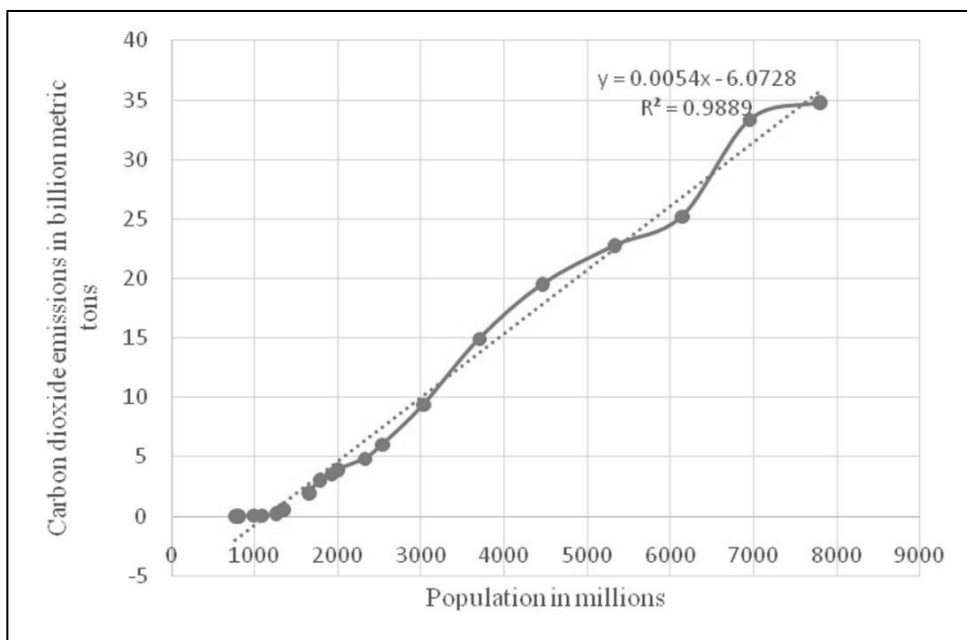


Fig. 2. Correlation between Carbon dioxide emissions and Population.

A larger population leads to increased energy consumption, requires larger production capacities and implies greater mobility, which in turn leads to higher levels of greenhouse gas emissions. In practice, population growth leads to an increase in energy consumption for heating, cooling, lighting, transportation, etc. In addition, increased consumption of food, goods and services also contributes to carbon emissions associated with agriculture, industry and transport. To reduce the carbon emissions associated with population growth, strategies for sustainable development and efficient use of resources are needed. This may include promoting energy efficiency in buildings, promoting renewable energy sources, improving public transport, moving towards more sustainable and ecological production and consumption models. In addition, education and public awareness play an important role in consciously reducing carbon emissions. Raising environmental awareness and promoting responsible consumption are essential to achieving a sustainable future.

In addition to the impact on carbon emissions, population growth will undoubtedly "help" generate municipal solid waste worldwide. This conclusion is analyzed from fig. 3, which compares the generated municipal solid waste in 2016 and the estimated for 2030 and 2050. In 2050, the volume of municipal solid waste generated is expected to reach 3.4 billion metric tons.

It is expected that with the growth of the population worldwide, an increase in the total volume of household waste be also assumed. This is the result of greater consumption of resources and increased production activity. The population of the planet continues to grow and is projected to reach 9.73 billion people by 2064 according to UN estimates. [16] A larger population leads to an increase in the consumption of food, energy, materials and other resources. This in turn contributes to the increase in the volume of produced waste. Household waste includes different types of materials such as plastics, paper, cardboard, glass, metals and organic waste. The growing volume of household waste represents a significant challenge for waste management and environmental protection. This can lead to overloading of existing waste collection, treatment and disposal systems.

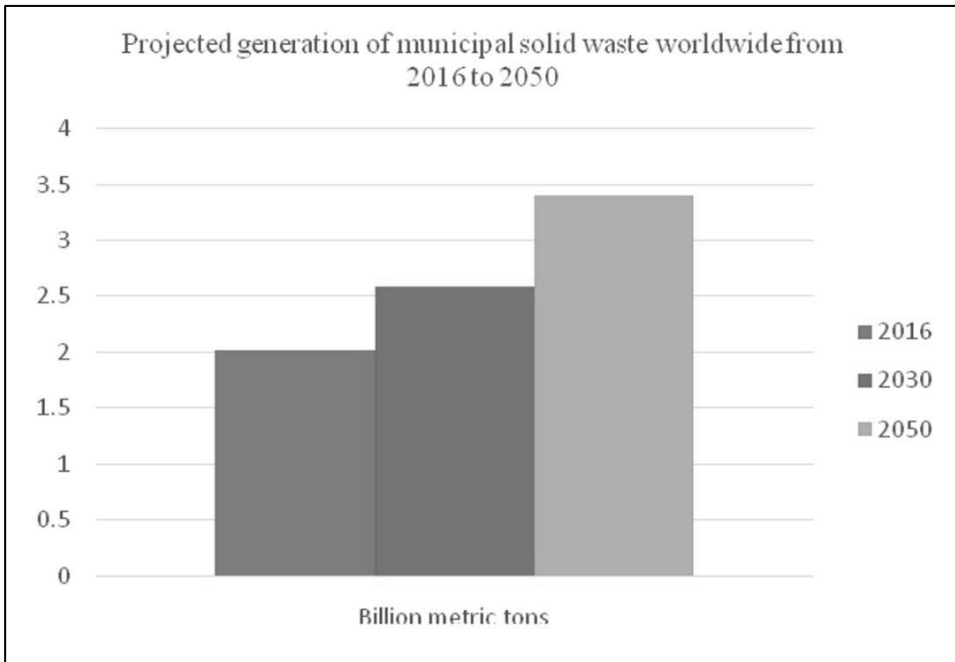


Fig. 3. Projected generation of municipal solid waste worldwide from 2016 to 2050.

Waste can cause soil, water and air pollution, which has negative environmental consequences. For humanity to meet this challenge, it is necessary to promote sustainable waste management practices and the transition to a circular economy. This includes using resources more efficiently, recycling, and recovering materials, reducing waste and promoting sustainable consumption. The introduction of policies and measures to change consumer behaviour, support innovation and investment in waste management infrastructure are essential to address the challenges associated with waste generation.

8 Conclusion

The publication presents estimates that have a significant and direct role in achieving environmental sustainability. The analysis indicates an increase in the usage of circular materials and the implementation of circular business models within the EU, and expects an increase in the rate in the coming years. Circular business models are thought to help reduce carbon emissions in the future. The study indicates a robust, almost functional link between pollution and population. It is anticipated that as the population expands, so will the amount of municipal solid waste and carbon emissions.

The analyzes carried out unequivocally prove the potential of the circular economy to be considered as a tool for the conservation of natural resources and the protection of global ecosystems in support of health and well-being, now and in the future. A large part of the decisions that affect the environment are not felt immediately, therefore a key element of environmental sustainability is its focus on the future. To achieve environmental sustainability, the following approaches are encouraged:

1. Resource efficiency – optimal use of energy, water, food, materials and other resources, minimizing loss and waste.

2. Renewable energy sources - the transition to the use of renewable energy sources such as solar, wind and hydropower is important to reduce dependence on fossil fuels and reduce carbon dioxide emissions.

3. Protection of ecosystems - preservation of species diversity and maintenance of ecological balances in ecosystems is essential.

4. Recycling and waste reduction – recycling waste helps to reduce the need to extract new raw materials and reduces the amount of waste that ends up in landfills.

All these approaches are principles of the circular economy and will help achieve environmental sustainability.

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