

Circular Economy and Sustainable Consumption

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Abstract: *World is facing severe economic as well as environmental problems due to rapid industrialization, over-use of natural resources for extraction of raw material, and exponential growth of consumption patterns. On the other hand, the finite natural resources, especially in agriculture, are under constant threat of scarcity due to meeting the food/feed/fiber needs of growing population. The linear economic model worsens the situation as it is based on “take-make-dispose” approach and hence does not support recycling, repair, reuse, or remanufacturing of existing products. Circular economy (CE) has emerged as a significant approach in terms of waste reduction, natural resources conservation and sustainable development in many sectors including agriculture. It plays a vital role towards achieving the many of the United Nations’ (UN) sustainable development goals (SDGs) such as poverty eradication (SDG 1), sustainable production and consumption patterns (SDG 12), dealing with the climate change (SDG 13), and protecting the ecosystem (SDG 13, 14). Circular economy offers a sustainable solution to the current non-environment friendly practices through different strategies and principles such as designing out the waste, keeping the products/material in use, regeneration of natural ecosystem, using renewable energy/sources, collaboration and system thinking, innovation and adoption of new technologies, and consumer engagement and behavior change.*

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5.1. Introduction

The need for materials and natural resources, which are the cornerstones of the economic system, has increased throughout the past several decades with an exponential growth in human population (Sohail et al. 2024; Murtaza et al. 2022). On the other hand, the environmental problem associated with the waste generation worsens as the final disposal facilities are concerned (Riaz et al. 2022) and they are ultimately contributing environmental degradation as the loop is not closed (Riaz et al. 2024; Murtaza et al. 2010). But it's important to understand that there are limited amounts of natural resources (Riaz et al. 2022). The earth's climate is undergoing rapid changes due to a combination of various human activities as well as the continuous advancement of technology (Ilić et al. 2020; Ilić et al. 2021a, 2021b, 2021c, 2021d; Stojanović Bjelić et al. 2022; Ilić et al. 2022; Stojanović Bjelić et al. 2023; Farooqi et al. 2023; Riaz et al. 2024; Ilić et al. 2024). The circular economy concept offers a workable way to stop the detrimental effects that climate change, environmental degradation, and resource shortages are having on the world (Haque et al. 2023). Its capacity to reduce the consumption of natural resources and the discharge of waste into the environment is its main advantage over the conventional linear economic model. The circular economy (CE) aims to reduce pressure on natural resources, create economic opportunities through new business models and job creation in the reuse and recycling industries, and increase resilience to resource price volatility and supply disruptions by keeping products and materials in use for as long as possible through reuse (See Fig. 6.1), recycling, and re-manufacturing (Barros et al. 2020; Nešković Markić et al. 2019, 2021). Businesses, governments, and consumers must work together to execute major changes in consumer behavior and manufacturing processes, as well as to create legislation that encourages circular behaviors, in order to transition to a circular economy (Velenturf et al. 2021).

As a revolutionary approach to sustainable resource management, the circular economy stands in a stark contrast to the conventional linear "take-make-dispose" concept (Geissdoerfer et al. 2017). The main goals of a circular economy are to design out waste and pollution, make sure resources and products are used for as long as feasible, and restore natural systems. In order to establish a regenerative system that reduces environmental effect and promotes economic

growth, this model places a strong emphasis on resource efficiency. Adopting the concepts of the circular economy allows organizations to prioritize sustainability in their business models and operations, which not only reduces waste but also opens up new economic opportunities (Kapoor et al. 2020). This transition to a circular economy is crucial for tackling the urgent problems of resource depletion and environmental degradation, eventually leading to a more sustainable future for all (Ellen MacArthur Foundation 2019).

The trend toward circularity emphasizes how important closed-loop systems, resource efficiency, and material recovery are to reducing environmental impact and promoting sustainability over a long time (Stahel 2016). This idea has gained popularity in a variety of fields, including manufacturing, consumer products, urban planning, and policy-making, demonstrating its capacity to deal with urgent worldwide problems including resource depletion, waste production, and climate change. Closed-loop systems try to establish an economy in which things are recycled, restored, or reused to almost completely eliminate waste and turn them into useful resources (Mujtaba et al. 2023).

The circular economy prioritizes sustainability and employs creative business structures and practices to solve environmental issues while simultaneously fostering economic growth. The potential for major improvements in the environmental and economic consequences is becoming more evident as more organizations realize how important it is to use circular practices (Kirchherr et al. 2017). The circular economy (See Fig 6.2) is an economic concept that aims to replace the traditional linear development model, sometimes known as the "take-make-dispose" strategy (Velasco-Muñoz et al. 2022) and it is designed to be in accordance with modern reality. This approach provides a strong emphasis on the value of sustainable practices, waste reduction, and the effective use of resources (Rekleitis et al. 2020) (See Fig. 6.1).

Long-term resource, product, and raw material usage is the main goal of a circular economy, which also looks for ways to reduce waste and increase value. This strategy is essentially different from the linear economic model, which is predicated on the extraction of raw materials, the production of commodities, and the final disposal of waste without considering recycling or reuse (Bigdeloo et al. 2002). This modification not only solves urgent global issues like resource depletion and waste production, but it also promotes economic growth by emphasizing sustainability in innovative business models (Croitoru et al. 2024). In this chapter, we have discussed the possible implementation of CE in agriculture sector.

The circular economy presents new approaches and innovative improvements that include environmental and economic considerations. In order to create more

resilient and sustainable production and consumption systems, it involves reconsidering design models and promoting the use of best practices (CEF 2024).



Fig. 6.1. Waste Hierarchy in Circular Economy

Сл. 6.1. Хијерархија отпада у кружној економији

The concept of the circular economy has undergone changes throughout the years, resulting from a variety of historical and modern influences (Ghisellini 2016). The principal advancements consist of:

Economic Theory. For years, the maximization of resource efficiency and the minimization of waste have been fundamental principles in economic theory. Economists like Nicholas Georgescu-Roegen and Kenneth Boulding have highlighted the cyclical nature of resources with well-known concepts like "waste equals food" and "cradle-to-cradle" thinking (Gkountani et al. 2022).

Agricultural Ecosystems. An agricultural system that makes use of ecosystems is one that increases biodiversity while promoting the use and advantage of natural processes such as biological balance, organic decomposition, soil regeneration, and nutrient cycling. A more circular agricultural system promotes higher economic, social, and environmental efficiency (Pham et al. 2024).

CIRCULAR ECONOMY Model focusing on sustainability through reusing, repairing, and recycling existing materials and products	
Principles	Designing out waste and pollution, keeping products and materials in use, regenerating natural systems
Benefits	Minimizing CO ₂ emissions, reducing consumption of raw materials, opening new market prospects
Impact	Can reduce 9.3 billion tons of CO ₂ equivalent by 2050 in sectors like cement, aluminum, steel, plastics, and food
Business Models	Product-as-a-service, sharing platforms, product life extension models enable the shift to circular processes
Contrast with Linear Economy	Linear economy follows 'take, make, waste' approach, while circular economy aims for reuse, repair, and recycling to create a closed-loop system
Implementation	Strategies can be applied at various scales from individual products to entire cities, promoting resource exchange and sustainable lifestyles

Fig. 6.2. An overview of Circular Economy System
Сл. 6.2. Преглед система кружне економије

5.2. Types of Organic Materials

5.2.1. Agricultural residues

Agricultural residues are carbon-rich materials produced as byproducts during the harvesting and processing of crops. These residues can be categorized into primary or field-based residues, generated during harvesting, and secondary or processed-based residues, which arise during the processing of the crops (Phiri et al. 2023). Their heterogeneous nature influences how they are handled throughout operations because of differences in bulk density, moisture content, particle size, and distribution. These residues are generally fibrous, poor in nitrogen, and their properties might differ greatly depending on the geographic factors (Duque-Acevedo et al. 2020). Field residues are sometimes repurposed as fertilizers, used for erosion control, or fed to livestock. However, nearly half of these residues are burned on farms before the next planting season begins.

Livestock industry is benefitting the mankind in several and hence fostering the economy as well. (Riaz et al. 2023; Kareem et al. 2023). Crop residues (leaf litter, seed pods, stalks, stems, straws, husks, weeds), livestock wastes (urine, dung, wash water, residual milk, waste feed), poultry wastes (spilled feed, feathers, droppings, bedding material), slaughterhouse wastes (blood, hair, hides, flesh, bones, etc.), agro-industrial wastes (bagasse, molasses, peels (orange, potato, cassava), pulps (orange, apple, mango, guava, pineapple, papaya, tomato, etc.), oil-seed cakes (palm kernel cake, groundnut, soybean, mustard, coconut, etc.), and aquaculture wastes (uneaten feed, faecal waste) are the main categories of AWs that have raised the public concern and threatened the sustainability of agricultural regimes (Seidavi et al. 2019; Duque-Acevedo et al. 2020).

5.2.2. Types of agro-industrial Wastes

An important factor in the development of human civilization has been agriculture. Early human communities were able to settle down and establish social, cultural, and economic structures due to the steady supply of food that came from the rearing of cattle and the cultivation of plants (Rohne Till 2022). The revolutionary effects of agriculture included promoting business, contributing in population increase, and eventually influencing the structure of the world economy. Agriculture faces enormous pressure to supply rising food demands due to rapid population increase (Duque-Acevedo et al. 2020; Foley et al. 2011). Currently, 23.7 million tons of food is produced worldwide each day (FAO 2022). This expansion has led to environmental deterioration, endangering ecosystems, soil, air, and water resources as well as human health.

Agro-industrial wastes fall into three main categories: hazardous agricultural and agro-industrial wastes, non-recyclable and non-compostable agricultural and agro-industrial wastes, and recyclable and compostable or naturally occurring agricultural and agro-industrial wastes (Rojas et al. 2022). Wastes that may be recycled at recycling facilities or utilized again on farms are known as compostable wastes. Pit, shell, peels, husk, cake, slurry, and slaughterhouse wastes are classified as secondary wastes because they come from agro-allied industrial processing, whereas pruning, straw, leaves, stover, stalk, bagasse, cob, and animal dung or manure are classified as primary residues because they are directly from crop and animal production activities.

Primary and secondary residues are typically regarded as the least problematic to manage. Wastes from agricultural mechanization, transportation, animal protection facilities, and building operations are classified as non-recyclable agro-industrial wastes. Due to their mass and lack of on-farm recycling or reuse, they

are the hardest to handle. These consist of tires, anti-stone nests or shadings, irrigation systems, metal structures for fences or coverings, plastic sheets and containers, and metal containers and equipment. If not properly managed, hazardous agro-industrial wastes can cause extremely serious problems both now and in the future (Ogbu et al. 2023).

They consist of chemicals, detergents, agro-chemicals, waste water, fertilizers, acids, phyto-sanitary goods, and other items like food, waste water, and polluted water (Kareem et al. 2023). The appropriate authorities have established regulations for the management of these wastes. In this review, we concentrate on the use of recyclable (primary and secondary) agro-industrial wastes (agro-industrial residue) in the manufacturing of functional products and renewable energy for use in household, industrial, veterinary, medical, and animal production applications.

5.3. Circular Economy Principles

The goal of the Circular Economy (CE) is to reinterpret traditional linear models of production and consumption, marking an evolution in economic thought (Chandratreya et al. 2024). This section explores the fundamental ideas, significance, advantages, and uses of the circular economy, clarifying its significant effects on resource management and sustainability (See Fig. 6.3). First of all, here are the core principles of CE.

5.3.1. Designing out the Waste:

First principle of the CE is the eradication of the concept of waste through scheming products and systems in such a way that eventually reduces the waste and pollution generation. It comprises the strategies such as to design the product with better durability, repairability options, and recyclability.

5.3.2. To Keep Products and Material in Use:

CE principles particularly highlight the significance of longer product-life by different strategies such as refurbishment, reuse, remanufacturing and recycling. Products can be kept within the same economic cycle for longer duration by their lifespan extension.

5.3.3. Regeneration of Natural Systems:

CE targets to restore and regenerate the natural systems through the adoption of sustainable practices for the minimization of the environmental impact. This

comprises the sustainable management of resources, restoration of habitat, and promotion of renewable energy sources.

5.3.4. Using Renewable Energy and Resources:

One of the key features of CE principles is to make a shift in the direction of renewable energy sources and creating sustainable regeneration resources. This decreases the dependency on limited resources, diminishes the environmental degradation, and encourages the sustainability in long-terms.

5.3.5. Collaboration and System Thinking:

CE promotes the collaborating between stakeholder, industries and communities in order to generate and system based on closed-loop. This schematic approach reflects the whole lifecycle of product starting from its designing and production to the final consumption and disposing for the optimization of resource use and minimizing waste.

5.3.6. Innovation and Adopting New Technologies:

In order to assist the transformation into a circular economy, it is vital to adopt innovative new technologies. Modern technologies including digitalization, radical manufacturing, and artificial intelligence (AI) personate the chief role in optimization of resource use as well as encouraging sustainability.

5.3.7. Consumer Engagement and Behavior Change:

CE underscores the significance of awareness among consumers regarding sustainable use of products. To make the CE model successful, it is inevitable to engage consumers in sustainable consumption practices, promotion of a shared economy, and also to advocate the adoption of sustainable practices.

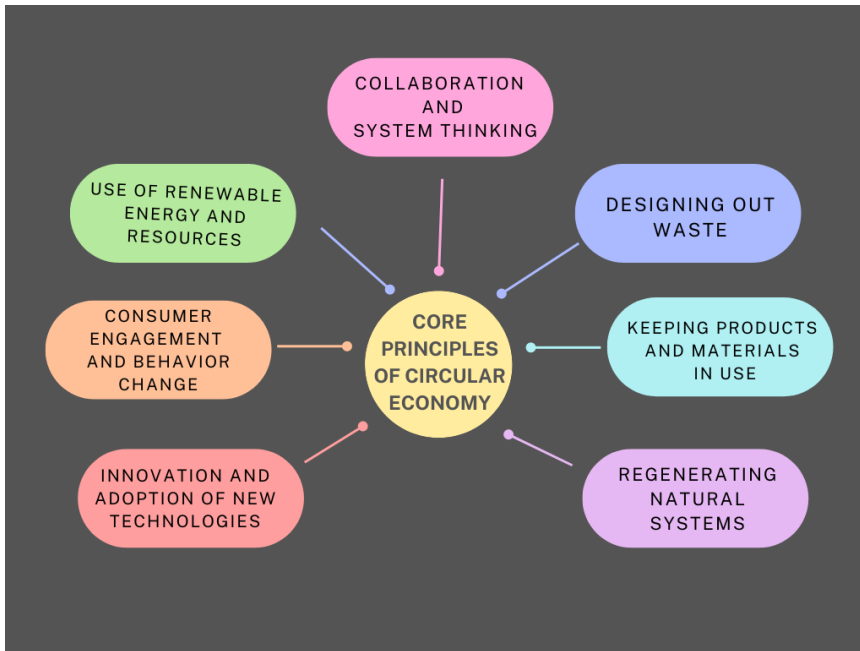


Fig. 6.3. Principles of Circular Economy

Сл. 6.3. Принципи кружне економије

5.4. Circular Economy and Sustainable Development Goals (SDGs)

The adoption of circular economy model might serve as a global solution to several environmental problems as well as guiding light to achieve the multiple sustainable development goals (SDGs) by 2030 (Rodriguez-Anton et al. 2019). Circular economy can pave the way towards sustainable development through its strategic approaches including waste reduction, material reuse, and the promotion of renewable energy and sources. Transformation from linear to circular economic model can lead to the achievement of many SDGs (Belmonte-Ureña et al. 2021) such as: addressing poverty (SDG 1), quality education (SDG 4) through offering skill development and entrepreneurship opportunities, gender equality (SDG 5) by providing employment opportunities to women in the male-dominant sectors such as recycling and renewable energy, access to clean water and sanitation (SDG 6) by efficient natural resources management and wastewater treatment strategies, affordable and clean energy (SDG 7) by integration of renewable energy sources and improving energy efficiency (Schroeder et al. 2019), fostering decent work and economic growth (SDG 8) by improving economic growth and creating more job opportunities, promoting sustainable production and consumption patterns (SDG

12) (Berg et al. 2018) through different strategies such as reuse, recycling, repairing, product life extension, and remanufacturing by minimizing waste generation, discoursing climate change (SDG 13) through adoption of renewable energy sources and innovative energy efficient technologies and enhancing climate resilience, protecting ecosystem on both below water (SDG 14) and life on land (SDG 15) by sustainable natural resources management, habitat and biodiversity conservation.

5.5. Importance and Paybacks of the Circular Economy (CE)

The CE model proposes several benefits and possesses crucial value when it comes to address numerous social, environmental, and economic challenges. The transition of typical linear model into an innovative circular model gives rise to a transformative shift holding extensive applications.

5.5.1. Resource Conservation and Efficiency

Highlighting the need of better resource conservation and efficiency is one of most vital benefits of circular economy. CE encourages more sustainable natural resources consumption by the maximum value extraction form prevailing resources and decreasing the waste generation. The adoption of practices such as reuse, repair, and recycling eventually lead to the resource conservation, decreases the raw material extraction necessity, and also mitigates the environmental depletion.

5.5.2. Reduced Environmental Impact

Systematically, CE model through its different principles eventually escorts to a decreased environmental degradation thru different sectors (See Fig. 6.4). CE nurtures environment-friendly sustainable practices by different means such as pollution minimization, greenhouse gas emission reduction, and mitigation of habitat degradation. Communities can suggestively decrease their environmental footprint and promote environmental management by adopting the eco-design, sustainable sourcing, and waste minimization strategies.

5.5.3. Economic Growth and Innovation

The CE motivates the growth and innovation from an economic perspective. CE promotes the economic diversification and resilience through promoting innovation, motivating job opportunities, and generating new business ideas. New

markets for recycled materials, re-manufactured goods, and service-based business models opening are causing economic growth and social betterment.

5.5.4. Cost Saving and Resilience

Enhanced resilience and cost-savings are two supplementary advantages of transformation into a circular economic model. CE encourages economic competence and effectiveness by the optimization of resources consumption, reduction of waste management costs, and minimum dependence on raw materials. Moreover, expansion of supply chains and decreasing the reliance on limited resources support the resistance to the supply chain destruction and price instability.

5.5.5. Social Benefits and Community Engagement

Social benefits and community engagement are vital parts of CE model. CE encourages the social unity and welfare by creating job opportunities in sectors like recycling, repair, and re-manufacturing as well as authorizing consumers by sustainable resources consumption. More resistant and comprehensive societies can be built by broader economic opportunities and unbiased resources access.

5.5.6. Reducing Dependency on Finite Resources

To lessen the reliance on limited natural resources is another important feature of the CE. CE encourages the resource security and resistance to shortage by promoting use of renewable sources, designing products with better lifetime and recyclability, and reducing resource withdrawal. This transition en route to renewable energy resources and sustainable manufacturing practices lines up with the global attempts for the mitigation of climate change and shift to comparatively low-carbon economy.

5.6. Importance of Reducing Waste and Promoting Resources Efficiency

Decreasing waste and encouraging the resources efficiency is the supreme approach of circular economy among many other environmental benefits in terms of sustainable development and environmental management (See Fig. 6.4). The effective utilization of natural resources protects the natural resources as well as diminishes the carbon emission and environmental depletion linked with the

exploitation, extraction, production, and disposing-off practices (Smith et al. 2018). Furthermore, the reduction in waste can significantly lead to the economic savings through dropping the production costs, improving the material use, and generating possibilities for recycling and up-cycling (Jones & Williams, 2020). In addition, the implementation of resource-efficient practices can promote innovation, encourage green-technologies, and improve business competitiveness globally (Brown & Clark 2019). Hence, waste reduction prioritization and resources efficiency is inevitable in order to attain a more sustainable and resistant socio-economic structure (Taylor et al. 2021).

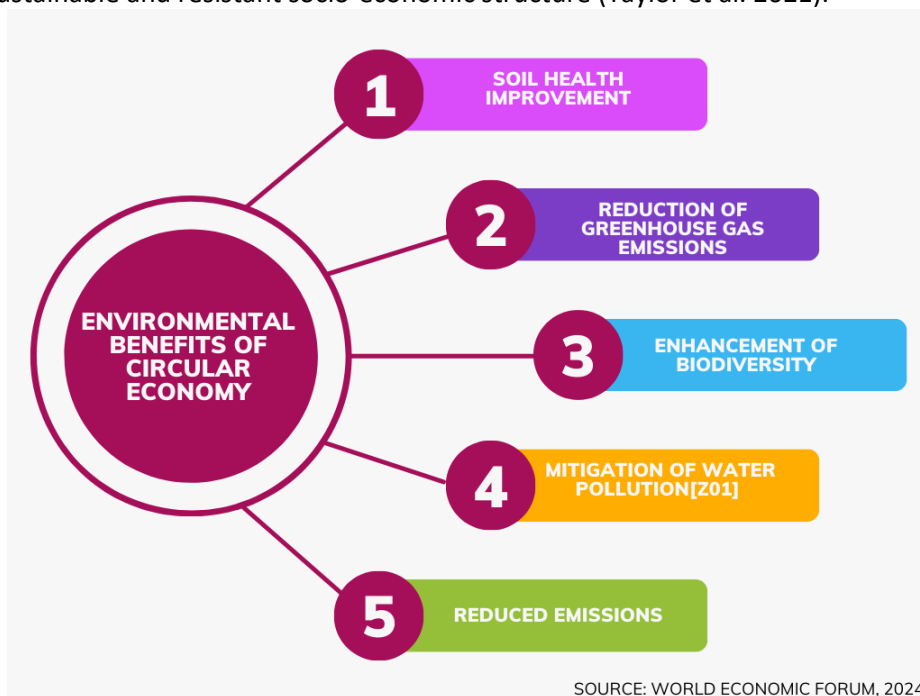


Fig. 6.4. Environmental Benefits of Circular Economy

Сл. 6.4. Еколошке предности кружне економије

5.7. Challenges, Solutions and Future Perspectives

The unsustainable resource consumption and excessive waste generation in current linear economy requires an intense need of transition to the circular economy principles (Geissdoerfer et al. 2017). The linear economy that is based on the “take-make-dispose” principle has caused the exhaustion of natural resources, environmental destruction, and excesses waste generation, hence posturing major challenge to the global sustainability (Stahel, 2016). The adoption of CE model requires a transitioning procedure for addressing these prevailing

issues through resource efficiency promotion, waste reduction, and promoting sustainable production and consumption models (Kirchherr et al 2017). The major goal of circular economy is to detach the economic growth from resource exploitation and environmental depletion by closing the product lifecycle loop thru various strategies including reuse, recycling, and re-manufacturing (EllenMacArthur Foundation 2013), hence leading to a long-term environmental and socio-economic balance and progress.

5.8. Conclusion

Since industrialization, the constantly rising global human and animal population is demanding increased food production that is causing immense waste generation and environmental degradation. The transition from linear to the circular economy is considered to be the ultimate approach to tackle the multidimensional problems currently faced by mankind such as climate change, exponential growth in population and resources consumption. Circular economy offers the efficient way to reduce waste and conserve environment by reusing, repairing, recycling, and remanufacturing. It also encourages creating public awareness and adopting strategic options that will eventually turn waste into wealth and a closed loop production system. Circular economy suggestively promotes the achievement of sustainable development goals by encouraging the resource efficiency, innovative technologies, and sustainable business practices. The assimilation of circular economy principles into policy frameworks and economic practices can help addressing the global economic, social, and environmental challenges. Conclusively, this paradigm shift to a circular economy is the best solution to accomplish sustainable development as well as for building a better, comprehensive, and resilient future for mankind.

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Кружна економија и одржива потрошња

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Сажетак

Свијет се суочава са озбиљним економским, али и еколошким проблемима због убрзане индустријализације, прекомјерне експлоатације природних ресурса за добијање сировина и експоненцијалног раста потрошачких навика. С друге стране, ограничени природни ресурси, нарочито у пољопривреди, под сталном су пријетњом осиромашења због потребе да се обезбиједе храна, храна за стоку и влакна за растућу популацију. Линеарни економски модел погоршава ситуацију јер се заснива на приступу „узми – направи – баци“, те стога не подржава рециклирање, поправку, поновну употребу или ремануфактуру постојећих производа. Кружна економија појавила се као значајан приступ у смислу смањења отпада, очувања природних ресурса и одрживог развоја у многим секторима, укључујући и пољопривреду. Она игра кључну улогу у остваривању многих циљева одрживог развоја Уједињених нација (ЦОР), као што су искорјењивање сиромаштва (ЦОР 1), одрживи модели производње и потрошње (ЦОР 12), суочавање са климатским промјенама (ЦОР 13) и заштита еко-система (ЦОР 13, 14). Кружна економија нуди одрживо рјешење за тренутне нееколошке праксе кроз различите стратегије и принципе, као што су дизајн без отпада, одржавање производа/материјала у употреби, регенерација природних еко-система, коришћење обновљивих извора енергије, сарадња и системско размишљање, иновације и усвајање нових технологија, те укључивање потрошача и промјена у понашању.

Кључне ријечи: кружни економски модел, одрживи развој, пољопривреда, циљеви одрживог развоја (ЦОР), очување, управљање ресурсима