5. THE CIRCULAR ECONOMY IMPLEMENTATION IN THE FOOD SYSTEM—THE LIFE CYCLE PERSPECTIVE

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Abstract

The circular economy concept aims to create value for society and the economy while reducing environmental impacts. The circular economy is based on three principles driven by design—eliminate waste and pollution, circulate products and materials (at their highest value), and regenerate nature. These principles can be applied to the food system, across all aspects of food design, from product concept, through ingredient selection and sourcing, to packaging. In order to assess the environmental load of any process or product in the food system, life cycle-based tools should be applied, since it can be beneficial and has potential for providing a holistic approach. This paper summarises the life cycle-based tools that have potential for complimenting the circular economy implementation in the food system. Based on that, the study identifies the current challenges as well as benefits and life cycle-based tools potential for providing a holistic approach that could strengthen available circular economy solutions.

Keywords: circular economy, life cycle assessment, sustainable product, food system.

JEL codes: F64, K32, N54, O13, O44, Q01, Q05.

Introduction

The circular economy (CE) concept is becoming more and more popular nowadays and is discussed widely in Europe and elsewhere. The reason for that is very simply—a shift from the linear economy, known as the "take-make-dispose" system, to the regenerative one seems to be necessary to protect the environment, reduce raw material dependence and boost innovation across different sectors of the economy (Chizaryfard et al., 2021; Kristensen & Mosgaard, 2020; Sánchez Levoso et al., 2020). The climate crisis also raises the need for taking rapid action aimed at improving the current state of the environment. The primary means of

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seeking to reach this aim should be achieving the Sustainable Development Goals (SDGs). The discussion about achieving the objectives of sustainable development set out in the Agenda 2030 shows that its implementation into practice is hard and has started to lose momentum (Paloviita & Järvelä, 2019) or has even begun calling sustainability "a theoretical dream" (Naudé, 2011) or living in the age of "sustainababble", which shows the profusion of using the word sustainable to mean anything environmentally better (Engelman, 2013). The CE concept is perceived as an approach relating to achieve local, national and global sustainability as well as operationalisation to implement the concept of sustainable development and achieve a sizeable number of SDG targets (Haupt & Hellweg, 2019; Kristensen & Mosgaard, 2020; Murray et al., 2017; Pauliuk, 2018; Schroeder et al., 2018; Suárez-Eiroa et al., 2019). The CE is focused on competitiveness and innovation, thus leading to corporate financial returns and further economic development (United Nations, 2015). In this perspective, the concept of CE has been recognised by the European Union (EU) as one of the biggest challenges.

5.1. Theoretical background of circular economy

In the literature, we may find a number of definitions of CE (Geissdoerfer et al., 2017; Kalmykovaa et al., 2018; Khan et al., 2022; Kirchherr et al., 2017). Although the theoretical foundations concerning the CE concept are not new, there is still no consensus in defining and conceptualising it (Homrich et al., 2018; Moraga et al., 2019). The most common description presents the CE as an "industrial system that is restorative or regenerative by intention and design" (Ellen MacArthur Foundation, 2013) or an economy "where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised" (European Commission, 2015). As mentioned before, the CE is a complete opposite to the linear approach. Following the CE concept organisations or businesses are focused on what happens to the product once it is thrown away. The assumption in the CE is that the availability of natural resources to manufacture the product is limited, and there is an important necessity to be concerned about the depletion of resources. The concept of quality associated with newness present in the linear economy is turned around (Stahel, 2016). There is a shift from the "cradle-to-grave" model, which is based on the take-make-consume-throw away pattern to the "grave-to-grave" one (McDonough & Braungart, 2010). When a product reaches the end of its life, its materials are kept within the economy, wherever possible and reasonable, and for as long as possible. It means that materials can be productively used again and again, in closed loops, for re-usage and creating further value. Such change in economic behaviour supports the CE movement and have a positive impact on its implementation. In practice, the CE focuses on reducing waste to a minimum as every product needs to be perceived as waste at the very beginning of its life (from the design phase).

The concept of CE is currently under ongoing discussion, especially concerning its definition and conceptualisation (Homrich et al., 2018; Korhonen et al., 2018; Moraga et al., 2019). It is also connected with an internal political agenda and regulations in this respect across Europe and in other developed countries (Ellen MacArthur Foundation, 2013; OECD, 2016; UNEP, 2011; World Economic Forum, 2023). As a consequence of the continuous and sustained efforts to adopt to the green economy and green growth concepts, the CE is still interpreted differently depending on the role and specific interests or priorities of stakeholders (Corona et al., 2019; Hartley et al., 2020; Jabbour et al., 2020; Kirchherr et al., 2017; Mayer et al., 2019; Valls-Val et al., 2000).

5.2. Circular economy principles

At the very beginning of the CE concept, there were only three principles—sharing, leasing and reusing. Nowadays various principles have been used in academia as well as by practitioners. They are listed in Table 5.1.

Table 5.1. Circular economy principles

Description		Source
R-principles		
3Rs	Reduce, Reuse, Recycle	Lieder & Rashid, 2016
4Rs	Reduce, Reuse, Recycle, Recover	Kirchherr et al., 2017
5Rs	Rethink, Reduce, Reuse, Recycle, Repair	Li, 2011
6Rs	Reduce, Reuse, Recycle, Recover, Remanufacture, Redesign	Yan & Feng, 2014
7Rs	Reduce, Reuse, Recycle, Recover, Rethink, Resilient, Regulate	Xing et al., 2017
8Rs	Rethink, Redesign, Reduce, Reuse, Return, Repair, Recycle/recover, Refuse	Maia et al., 2019
9Rs	Refuse, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, Recover	van Buren et al., 2016
10Rs	Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, Recover	Potting et al., 2017
Other CE principles		
3 CE principles defined by the Ellen MacArthur Foundation	1) Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows, 2) Optimise resource yields by circulating products, components and materials in use at the highest utility at all times in both technical and biological cycles, 3) Foster system effectiveness by revealing and designing out negative externalities	Ellen MacArthur Foundation, 2015

Table 5.1 – cont.

Description		Source
6 CE principles defined by the Circular Economy Standard BS 8001:2017	1) System thinking, 2) Stewardship, 3) Transparency, 4) Collaboration, 5) Innovation, 6) Value optimisation	BSI, 2017
6 CE principles defined by Ghisellini et al.	1) Reduction, 2) Reuse, 3) Recycle, 4) Appropriate design, 5) Reclassification of materials into technical and nutrients, 6) Renewability	Ghisellini et al., 2016
7 operational principles of CE defined by Suárez-Eiroa et al.	1) Adjusting inputs to the system to regeneration rates, 2) Adjusting outputs from the system to absorption rates, 3) Closing the system, 4) Maintaining the value of resources within the system, 5) Reducing the system's size, 6) Designing for CE, and 7) Educating for CE	Suárez-Eiroa et al., 2019
3 CE principles defined by Bocken et al.	1) Narrowing loops, 2) Slowing loops, 3) Closing loops	Bocken et al., 2016

Source: adopted from (Papageorgiou et al., 2021).

In general, there are two types of core principles. One type relates to the R frameworks, and the other (other CE principles) focuses on the system's perspective, which states that the CE requires a fundamental shift instead of incremental twisting of the current system (Kirchherr et al., 2017). The first mentioned group of principles, the R frameworks, is perceived by many authors as the core principles of the CE, due to its "how-to" approach (Reh, 2013; L. Zhu et al., 2010; Q. Zhu et al., 2010). Moreover, the 3R framework is the basic and the very first approach to the CE and the 4R framework is the core of the European Union Waste Framework Directive (European Commission, 2008), which introduces an additional "R"—"recover", as the fourth principle.

Other R frameworks beyond the 3R and 4R frameworks, such as the 9Rs (van Buren et al., 2016) or even 10Rs (Potting et al., 2017) have been proposed. All types of the R framework share a hierarchy and shift from the linear economy to the circular one, where "recover" is nearest to the linear economy, but "refuse"—to the circular one. The first R, "recover" is the situation where the incineration of material with energy recovery takes place. The closest to the circular economy concept is to "refuse", where the product becomes redundant by abandoning its function or by offering the same function with a radically different product (Potting et al., 2017).

5.3. The circular economy in the food system

Implementation of the CE principles is among the priorities of the European Union reflected in the undertaken activities and related to the very basis of the consumer policy and legislative strategy employed by the Commission. The benefits associated with adopting the CE practices are increasingly perceived as an important and inherent factor of economic growth in both regional and national economic sectors (Ellen MacArthur Foundation, 2020; Patwa et al., 2021). Thus, this concept is increasingly being adopted by the current norms and standards. In March 2020, the European Commission adopted a new circular economy action plan focused on the seven sectors that use most resources and where the potential for circularity is high. One of the listed key product value chains is food, water and nutrients. As the model of production and consumption that incorporates the CE principles involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible (European Commission, 2020), the CE for food is close to natural systems of regeneration. In this concept, organic resources such as food by-products are clean and free from contaminants, which enables their return to the loop in different formats. In the food system, the most important rule of the CE is prevention and redistribution, as showed in Figure 5.1.

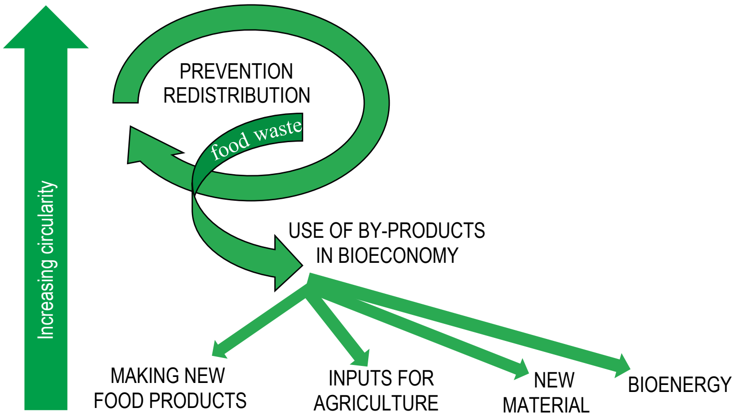

Figure 5.1. Principles of food system in circular economy
Source: on the basis at (Ellen MacArthur Foundation, 2019).

Prevention aims at tracking food waste and providing information in order to prevent edible food waste. It also covers the design phase, where food products are designed according to the latest eco-design trends. Prevention also includes the information phase, where all interested parties are informed about how to avoid food wastage. Redistribution aims to eliminate food waste. There are many ways of doing it, including serving meals as redistributed food to the needy. Food by-products generated at several stages of production can be used in the chain for different purposes, such as creating new products, producing new materials, such as fabrics for the fashion industry, inputs for agriculture (e.g. fertilisers) or as potential sources of bioenergy.

5.4. Circular economy in a life cycle perspective for the food sector

The importance of introducing the CE strategies in the food sector is very high. The food value chain is one of the main contributors to pollution worldwide and is responsible for significant resource and environmental pressures. Furthermore, it is currently estimated that about 20% of the total food produced is lost or wasted in the EU (European Commission, 2020). Additionally, on the one hand, there is exponential growth of total demand for food, feed and fibres, but on the other one, a relentless decline of arable land is observed (European Environment Agency, 2020). Moreover, in the food sector, direct or indirect interdependencies are very commonly observed in terms of resource competition for food or bioenergy, food loses and wastage and as consequence, which impacts the whole value supply chain. There are ten sustainability principles that affect the food value chain development, which are presented in Figure 5.2.

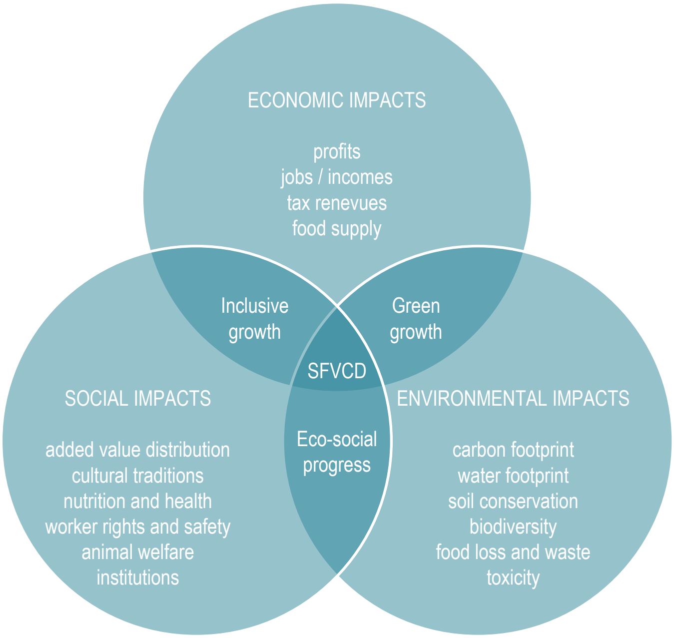

Figure 5.2. Sustainability principles of food value chain development
Source: adopted from (Neven, 2014).

These principles are a good path to present performance from the perspective of the triple bottom line: economic, social and environmental sustainability. The important thing is that all these three dimensions shall be treated together as they overlap, and only together give the complete picture of the state of the art.

There are a lot of pathways for improving the resource efficiency of food system activities. The application of the CE principles can encourage technical innovations for ensuring a more sustainable use of renewable resources and reduce environmental damages as well as depletion of non-renewable resources. Another important thing is assessing the environmental impacts of new circular strategies. For that purpose, the implementation of the Life Cycle Assessment (LCA) methodology can be useful (Ingemarsdotter & Dumont, 2022). This worldwide known tool used in environmental management allows us to assess the environmental impacts generated by an individual process of reuse, recycling or recovery of wastes or by-products. LCA makes it possible to identify and quantify environmental loads, as well as evaluate their potential environmental impacts and assess opportunities for their reduction. However, introducing LCA as a process of evaluating the environmental impact of the assessed product over the entire life cycle does not allow for assessing the effects in terms of circularity, both concerning the product that has generated waste and by-products as well as the product that will use them to work out new products (Rocchi et al., 2021; Silvestri et al., 2022; Stillitano et al., 2022). The solution for introducing the sustainability aspects may be to match the life cycle of the product whose circularity will be assessed with the life cycle of the product whose environmental impacts will be assessed, integrating circular strategies within system boundaries (Falcone et al., 2022). It is equally important to note that the sustainability aspects cover three spheres of environmental, economic and social impacts. It can be assessed in associated analysis including, respectively, the environmental Life Cycle Assessment (LCA), Life Cycle Costing (LCC) and social Life Cycle Assessment (S-LCA). The rules for providing such analysis are standardised and present in the current ISO 14000 standards series. Following the rules, the sustainable LCA analysis can support the evaluation of environmental, economic and social impacts of products or service systems or even (re)designing it. The obtained results do not provide information about the circularity aspects of the assessed product or service. This gap can be filled by using additionally the circularity indicators, which can measure the circularity of resources and material flows in LCA studies (Ingemarsdotter & Dumont, 2022; Stillitano et al., 2021). Two indicators are well-known and useful for this purpose. They are the Material Circularity Indicator (MCI), created and popularised by the Ellen MacArthur Foundation, and the Circular Transition Indicators (CTI) developed by the World Business Council for Sustainable Development (WBCSD). The former, MCI, measures which linear flow has been minimised and which restorative flow has been maximised, while considering the product's lifetime and intensity of use. It focuses on the flow of materials throughout the manufacture and use of the product and allows for including and introducing the use of recycled or reused materials as well as extending product life. The latter, i.e. CTI, allows for assessing material flows within company boundaries. The goal is to minimise resource extraction and waste material at three key intervention points: inflow, outflow—recovery potential, and outflow—actual recovery. All of them can be measured with specific indicators and the results can help with closing and optimising the loops, and this way helping to assess the circularity of products or services.

Nowadays there are attempts to assess circularity in the food supply system using Life Cycle Assessment (Nikkah et al., 2021; Papageorgiou et al., 2021). However, the life cycle tools have their limitations, which include: time intensive data collecting and gathering, missing impact data or models for LCA, data uncertainty, dependency on other tools for decision making, and allocation of ecological burdens among co-products (Curran, 2014). Moreover, it can be assessed that the development of CE indicators in the food sector is currently in a premature stage. There are many important open questions to answer. Particularly relevant issues are how to match the material efficiency approach with the systemic approach and where to put the boundaries of processes for defining indicators (Vermeyen et al., 2021).

Thus, there is a real need to provide future research in the field and to introduce specific circularity indicators, which can help to overcome important methodological and practical barriers.

Conclusions

Due to their relative novelty and dynamic changes occurring in the issues raised, there is a need for a standardised indicator-based framework that could be applied for measuring circularity in the food sector. Nevertheless, further research is needed to determine the right way of assessing circularity. Although the life cycle tools are very good for assessing it, future research should focus on developing and introducing a common framework. The present study is an additional voice in that discussion and can be useful as a starting point for further research in this area. It indicates the strengths and weaknesses of existing solutions and tools, which can be helpful in assessing circularity. Bringing the CE into practice and the economy is important, but we cannot forget about monitoring its progress influencing the rate of sustainable economic growth. In this context, further research should focus on identifying, improving and developing CE indicators that will reflect on all three dimensions and aspects of sustainable development. It is crucial to focus not only on the environmental aspects but also on the social, economic and governance aspects. Putting all these assumptions together is a challenge, but such an approach will allow us to ensure that the framework includes indicators able to capture aspects that are relevant to all pillars of sustainable development.

More practical research in the field of measuring circularity of different food sectors is also needed to provide empirical findings coming from different case studies and can be useful for application in the identified framework. The circularity of the food sector is one of the key areas that we need to focus on when improving its sustainability. In this context, there is an increasing need for introducing proper tools to measure and monitor progress towards the CE. Indicator-based frameworks seem to be a proper way to both measure and monitor progress towards the CE in the food sector. A systemic perspective of such activities is needed to capture the multiple dimensions and complexity of the transition towards the CE.

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