Circular Economy as a Tool for Sustainable Development: A Theoretical Perspective

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Abstract. Climate change, depletion of natural resources, social inequality and poverty, a lack of food resources, etc. issues related to world sustainable development has become increasingly relevant in the last 50 years, negatively affecting people's opportunities, and living standards in various countries. Despite these problems, the average level of wealth of the population in the world is gradually increasing over time. Considering forecasts on population growth by the end of the 21st century, it must be admitted that the current world-dominant linear economic model is fully unsustainable in resource consumption, as there is a natural barrier to economic growth. The aim of the present research study is to explore the potential of the circular economy as a tool for achieving sustainable development, based on a theoretical framework. This paper was built based on a broad literature review to examine the limitations and conceptual gaps of the circular economy concept as a tool for achieving sustainable development. It has been concluded that the circular economy concept undeniably has huge potential to promote sustainability within planetary boundaries as well as it can be implemented to decouple economic growth from the utilization of finite resources. However, a broader analysis of the circular economy concept allows us to assert that to date, a clear and effective approach for the transition to this economic model, affecting all areas of sustainable development (i.e. environmental, economic, social) has not been developed. In addition, the circular economy concept is still evolving, there is a tendency to view the circular economy concept holistically, covering various sub-concepts of the circular economy under the common Sustainable Circular Economy concept's umbrella.
Keywords: circular economy, planetary boundaries, resource consumption, sustainable development.

I. Introduction

The sustainable development (SD) framework encompasses strategies and practices aimed at reducing our ecological footprint while fostering development rooted in principles of social justice and equality. The three core dimensions of sustainability are economic, environmental, and social. True sustainability is attained only when there is an equilibrium or a careful trade-off among these three aspects [1], [2], [3].

Since the creation of a definition of SD in the 1980s, many stakeholders still seek workable solutions to achieving SD at the macro (local and national government) and micro (entrepreneur and consumer) level. However, it is a complex process affected by various external factors. The United Nations (UN) Department of Economic and Social Affairs forecasts that the world population will increase by at least 2 billion people by 2100 [4], while World Bank data indicate an increase in the wealth of nations and the proportion of the middle class since 1995 [5], [6]. Although overall the changes can be viewed positively, it simultaneously raises concerns about the risks of resource overconsumption and social inequality: the populations of Global South countries lack equal access to education, health care and balanced diets, on the other hand the overconsumption of resources by the people of Global North countries causes the depletion of world resources, increases the greenhouse effect and environmental pollution, thereby contributing to an increase in social inequality in the world [7], [8], [9], [10]. Teixidó-Figueras et al. [11] argue that the top 10% of global income earners contribute to 25-43% of the environmental impact. At the same time, the bottom 10% of income earners worldwide are responsible for only approximately 3-5% of the environmental impact. Obviously, the current levels of consumption by most people in the Global North, in most cases overconsumption, is unsustainable, unethical or unjust on a global scale.

UN Environment Programme data show that resource extraction has more than tripled since 1970, including a fivefold increase in the use of non-metallic minerals and a 45 percent increase in fossil fuel use; by 2060, global material use could double to 190 billion tonnes (from 92 billion), while greenhouse gas emissions

Print ISSN 1691-5402
Online ISSN 2256-070X
https://doi.org/10.17770/etr2024vol1.7954

could increase by 43 percent; the extraction and processing of materials, fuels and food contribute to half of total global greenhouse gas emissions and over 90 percent of biodiversity loss and water stress [12]. Given that the current world-dominant linear economic model is inherently unsustainable, it is obvious that it is necessary to change the paradigm of existence and development of society through eco-economic decoupling.

It should be noted that there is a lack of specific management models or tools for putting the SD framework into practice. Among different management models used in the 21st century, the model (concept) of the circular economy (CE) is the one meeting the prerequisites for SD in the most accurate way [13].

In contrast to the 'take-make-use-waste' linear model, a CE is regenerative by design and aims to gradually decouple growth from the consumption of finite resources [14] (see Fig. 1).

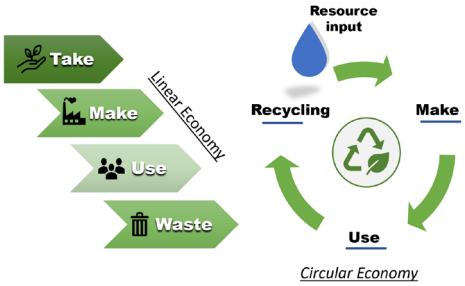

Fig. 1. Linear Economy model vs Circular Economy model (compiled by the author based on [2], [14], [15], [16], [17])

However, some authors criticize the CE for a lack of real definition, arguing that the goals and ways of implementation thereof are still unclear and inconsistent, and the limited conceptual basis thereof does not provide an idea of how the CE can contribute to SD [2], [15], [16], [17].

The research problem: despite the fact that the CE has emerged as a potential solution to achieving SD, there are still concerns and uncertainties about the implementation of the CE model, ignoring one or the other dimension of SD. Therefore, the main question of the research study is: could the CE be a tool for SD?

The research hypothesis: the dominant CE concept, which is primarily focused on resource efficiency, does not apply a holistic approach to linking economic growth, social justice and responsible environmental resource consumption. A theoretical analysis reveals the need for a more detailed CE concept to effectively integrate the above-mentioned dimensions, thus fostering SD.

II. Materials and Methods

The research methods applied: scientific literature review, reports and research papers by various organizations in the research field for comprehensive coverage of relevant research studies pertaining to the research question, logical construction for making judgments and analysis of results, the synthesis method for combining elements into a unified system for researching the concepts of SD and CE, the monographic method for an in-depth examination of specific scholarly works and comprehensive studies related to the research question.

III. The Evolution of the SD Concept

Historically, the concept of sustainability referred to the constraints of natural resources and economical use thereof, considering the need therefor in the long term and the future.

Table 1 Time periods and turning points in the formation of the SD concept (compiles by the author based on [1], [18], [19], [20], [21], [22], [23], [24], [25], [26], [27], [28], [29], [30], [31])

Time periods and turning points in the formation of the SD concept
First period: before 1972
1798: predictions by Thomas Robert Malthus about a lack of food resources due to the constant growth of the population;
1864: George Perkins Marsh's articles on the risk of human extinction due to interference with the natural environment;
Turn of the 18th and 19th centuries: the idea of sustainability appeared during the industrial revolution;
19th century: there were two factions within the environmental movement: conservationists who advocated the responsible use of natural resources and preservationists who advocated the protection of nature from use;
1950-1970: negative environment impacts of rapid economic growth, leading to concerns about sustainability;
1972: the Club of Rome report The Limits to Growth - a warning that the growth of population, industrialization, resource depletion and pollution in the next century could exceed the capacity of the Earth.
Second period: 1972–1987
1972: *The UN Conference on the Human Environment* in Stockholm was the beginning of a global change agenda introducing the concept of SD, which emphasizes the alignment of human development with environmental constraints; under the slogan '*Only One Earth*', a declaration and action plan for environmental conservation was published; the United Nations Environment Programme (UNEP) was launched;
1983: the Brundtland Commission report *"Our Common Future"* defined SD as development that *"meets the needs of the present without compromising the ability of future generations to meet their own needs"*; the basic principles of SD include satisfying human needs while considering certain environmental constraints; a transition to a global socio-economic policy, with SD becoming a key aspect in environmental management and other areas of human activity.
Third period: 1987 – present
1992: the Earth Summit in Rio de Janeiro developed Agenda 21 - an action plan for creating a global partnership to solve environmental problems; the social dimension was integrated into the SD concept: the three dimensions of SD were considered to be the economy, society, and the environment; a holistic approach to solving SD problems;
2000: the UN Millennium Summit defined a set of *the Millennium Development Goals* (MDGs) as a globally accepted framework to shape development and cooperation in countries over the next 15 years;
2012: the Earth Summit *"Rio +20"* in Rio de Janeiro adopted *"The Future We Want"* declaration on SD and the green economy, recognizing poverty as the main challenge to humanity and defined a set of *Sustainable Development Goals* (SDGs) beyond 2015;
2015: the UN Sustainable Development Summit assessed the implementation of MDGs and adopted *"Transforming our World — the 2030 Agenda for Sustainable Development"* (includes a set of 17 SDGs to be met by 2030, which are accompanied by specific targets – 169 in total), thus emphasizing coordinated economic, social and environmental development towards sustainability.

Shi et al. [18] and Klarin [19] have distinguished three historical periods in the evolution of the SD concept: (1) The Embryonic Period (Before 1972, or the

first period); (2) the Molding Period (1972–1987, or the second period), and (3) the Developing Period (1987–Present, or the third period) (see Table 1).

As shown in Table 1, initially, the concept of sustainability was mainly viewed in terms of lack of natural resources (environmental dimension of sustainability), yet over the course of two centuries, there has been a paradigm shift in the evolution of the SD concept, applying a holistic approach and integrating the social dimension into the SD framework.

IV. The Main Dimensions of SD

SD involves approaches and methods that reduce human environmental impacts and foster development based on social justice and equity. To achieve sustainability, it is necessary to harmonize the three dimensions of sustainability: economic, environmental and social, or at least reach a trade-off between them. There are several models that seek to conceptualize SD, and each of them provide a different interpretation of the three dimensions. The models could be represented in different ways, e.g. as "pillars", as concentric circles, or as interlocking circles (Fig. 2). As a result, the ambiguities have complicated the perception and understanding of the SD concept, which vary across literature sources [32].

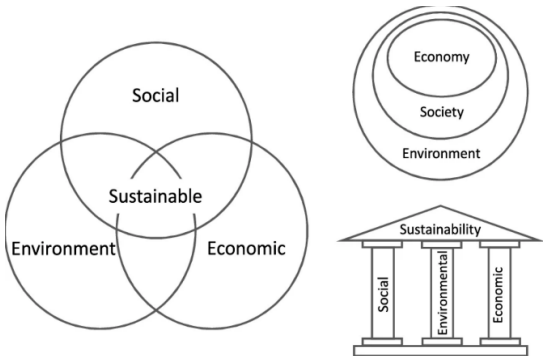

Fig. 2. Three dimensions of SD [3]

The recent reviews suggest replacing the environmental, economic and social dimensions with satisfying human needs, ensuring social equity and respecting environmental limits [33]. Despite this suggestion, it is widely recognized that in the context of SD, progress in one dimension should not come at the expense of the other two dimensions, and it is important to maintain a balance and take equal account of economic, environmental and social aspects in order not to harm overall sustainability [2], [34].

However, the widely used Brundtland definition [27] focuses on meeting global needs and ensuring intergenerational equity. According to research studies on SD, for an approach to be considered compatible with the principles of SD, it should not limit opportunities for future generations to live in conditions that are available to the current generation [35]. Accordingly, it could be concluded that the developments that disrupt or impede the ability of future generations to meet their own needs will not allow SD to be achieved if the three dimensions are not in harmony [2].

V. The Essence and Definition of CE

Tambovceva & Titko [36] have found that the CE concept was introduced by Pierce and Turner in 1990, developing a new economic model based on the principles of thermodynamics. Later this idea was explained by Ciegis and Ciegis [37].

The modern understanding of the CE is based on the principles of industrial ecology, the environmental economy and the green economy with the aim of reducing environmental pressure in industrialized nations [38], [39].

The basic principles of CE strategies are “reduce”, “reuse” and “recycle”, which are defined in the scientific literature as "3R" [38], [40], [41]; however, the European Union (EU) Waste Framework Directive refers to “4R”, with “recover” being the fourth R [42], as several definitions were found to refer to “regeneration” [43]. This framework has evolved into a framework of 10 strategies, with some authors referring to it as the “9R” [43], [44], or the “10R” (see Fig. 3).

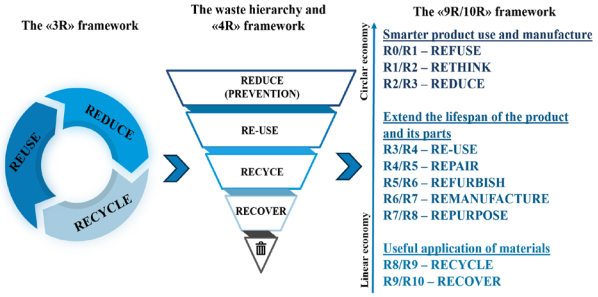

Fig. 3. Evolution of CE strategies (compiled by the author based on [38], [41], [42], [43], [44])

As regards the definition of CE, Millar et al. [2] have pointed out that no universal and generally accepted definition of CE has been proposed to date. The CE has gained momentum in the past decade, primarily through the approach of practitioners such as the Ellen MacArthur Foundation and often the CE is generally understood by the business world as *“a systems solution framework that tackles global challenges like climate change, biodiversity loss, waste, and pollution. It is based on three principles, driven by design: eliminate waste and pollution, circulate products and materials (at their highest value), and regenerate nature”* [14]. The CE concept as an alternative model that can promote production and consumption with lower environmental impact while promoting economic growth has been accepted in academic, policy-making and business circles [46], [47], [48]. The author points out that this widely accepted definition of CE does not include the social equity dimension, which is important if accepting the CE as a tool for achieving SD.

It should be noted that different definitions of CE have increasingly appeared in the scientific literature in recent years. In 2017, after analysing 114 definitions of CE available in the last decade, Kirchherr et al. [43] proposed defining the CE as “*an economic system that replaces the ‘end-of-life’ concept with reducing,*

alternatively reusing, recycling and recovering materials in production/distribution and consumption processes. It operates at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish SD, thus simultaneously creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations. It is enabled by novel business models and responsible consumers". It could be concluded that this definition covers all the three dimensions of SD (environmental quality, economic development, social equity). According to Kirchherr et al. [43], of the total CE definitions analysed, only 11 percent referred to SD as a principal aim.

In 2023, after re-analysing the recent CE definitions, Kirchherr et al. [49] concluded that all the three dimensions of SD were mentioned more frequently in the new set of definitions – a threefold increase compared with the 2017 study –, pointing out that fewer authors agreed that economic prosperity should be an aim of the CE. Kirchherr et al. [49] also pointed out that the largest shift since 2017 has been within CE enablers who are not only consumers and producers but also policymakers and scholars.

However, the most important conclusion made by Kirchherr et al. [49] is that considering the continually changing landscape of technology, environmental factors, and economic and socio-political contexts, the definitions of CE are expected to undergo a continuous evolution and ***"the development of a 'final' and consensus definition of CE is elusive"***, and all current attempts to define the CE simply *"illustrate where the academic field currently sits in its own understandings of CE"* [49].

VI. The CE as a Tool for SD

Millar et al. [2] argue that numerous contradictions and knowledge gaps exist regarding how the CE can improve social equity, promote economic growth and permanently reduce the rate of extraction of raw materials by closing material loops. And there have been no reviews that explicitly (i.e. by covering all the three dimensions of SD) analyse how the CE can serve as a tool for achieving SD.

To be able to answer the main question of the present research study, the limitations of the CE should be analysed, as pointed out by sceptical scholars who do not have a consensus about the contribution of the CE to sustainability [15], [50], [51]; therefore, the CE is viewed as simply a more environmentally sustainable model than the "linear" economy.

Despite the growing interest, the progress of the CE concept towards SD has not yet been formally identified. There are CE concepts that focus only on the reduction of raw materials and waste, the preservation of resource value and the reintegration of products [52], thereby indicating that the social dimension of SD is missing and creating potential limitations to achieving sustainability.

Limitations of the CE concept.

To be able to examine the limitations of the CE in more detail, the author of the study divided them into SD dimensions: economic, social and environmental, and also analysed the limitations of CE implementation (see Table 2).

Table 2 Limitations of the CE concept in SD context (compiled by the author based on [2], [16], [39], [43], [53], [54], [55], [56], [57], [58], [59], [60], [61], [62], [63], [64], [65], [66], [67], [68])

SD dimensions	Limitations
Environmental dimension	- The CE as a closed-loop system is not practically or theoretically possible due to the second law of thermodynamics, which states that the continuous need for energy in recycling processes inevitably creates waste and by-products, ultimately leading to resource depletion, pollution and waste generation; - The CE is seen as a potentially more environmentally sustainable tool than the linear economy. However, it could still lead to similar consequences of environmental degradation, albeit at a slower pace; - The "rebound effects" challenge arises in the CE model, where improved secondary production efficiency reduces costs, potentially leading to increased consumption; this could offset the initial environmental benefits gained from enhanced efficiency; - There is no evidence that secondary production in the CE model could fully replace primary production, as technological limitations prevent the breakdown of certain wastes and the treatment of certain liquids; - Extending product lifetimes proposed by the CE to reduce dependence on continuous extraction of finite virgin materials, poses uncertainties about its impact on material flows, threatening long-term sustainability and challenging the assumption that it is a better alternative to the current linear model.
Economic dimension	- Due to increasing consumption, achieving a closed loop in CE is not possible: *"if demand is growing, the circle cannot remain closed"*. The CE could be feasible only if global demand for products in terms of both volume and composition stabilizes; - Information resources on the CE do not emphasize the importance of changing consumption patterns: if the current unsustainable economic paradigm is not changed and consumption patterns are not revised, the CE may remain only a technical tool without enabling sustainability; - There is no certainty that the CE can stimulate economic growth without endangering the environment.
Social dimension	- Whilst the CE has the potential to benefit society, there is a lack of the social aspect being integrated into the current framework, especially with regards to issues of governance, justice, and cultural change; - The lack of social indicators, which prevents the evaluation of the impact of the CE on social aspects, which raises doubts about the ability of the CE to promote social equality; - The CE concept does not illustrate the ways in which the social equity on the intra-generational (between the Global North and South) and the inter-generational (between the current and next generations) levels could be promoted; - Limited extraction of natural resources proposed by the CE could be considered antisocial for developing economies that are still growing resource stocks to build infrastructure that are essential for well-being.

SD dimen-sions	Limitations
Implementation aspect	- There are still challenges in the implementation of SD strategies and tools, which suggests that the implementation of the CE could face similar problems: both "top down" (commonly characterized as implementation enforced by government institutions or their equivalents) and "bottom up" (generally identified as initiatives advanced from the individual level) approaches face conflicts with other stakeholders; - SD is a society objective concept defined at the macro-level ("top down" approach) while the CE approach is mainly defined at the micro-level ("bottom up") through a model of consumption and production; it is not clear if they meet mid-way; - There is a lack of comprehensive global overviews of CE implementation and its alignment with SD goals; - There are conflicting motivations among CE stakeholders that need to be aligned and combined for successful implementation; - There is a deficiency in collaboration among policymakers, governmental bodies, manufacturing industries, and consumers, along with an overall lack of vision on how they implement the CE; without the sharing of knowledge and responsibilities among stakeholders, there are no guarantees of enhancing the success of implementing the CE as a tool for SD; - The CE introduces a range of tools that can be utilized for sustainable purposes, yet the ultimate objective appears unclear and decidedly more limited than that of SD; - Implementation of the CE is always associated with extra cost as long as the benefit is greater than or equal to the cost.

After analysing Table 2, it can be concluded that the CE implementation within the environmental dimension faces significant challenges to achieving a fully closed-loop system. While the CE is seen as a potentially more environmentally sustainable economic model, concerns about rebound effects, technological limitations, and uncertainties regarding the extension of product lifetimes underscore the complexity of implementing it as a superior alternative to the current linear model.

Regarding the economic dimension, the feasibility of a closed loop in the CE is hindered by constantly increasing consumption, necessitating the stabilization of global demand for products in terms of both volume and composition. The lack of emphasis on changing consumption patterns and without addressing the unsustainable economic paradigm, the CE may merely function as a technical tool without achieving sustainability. Additionally, uncertainties persist regarding the potential of the CE to stimulate economic growth without posing risks to the environment.

The social dimension of the CE is also debatable. Obviously, the CE holds societal potential, but its current framework lacks integration of different social aspects as well as the absence of social indicators raises doubts about the CE's ability to promote equality and address global and intergenerational disparities. Additionally, the CE's proposed limited resource extraction may be considered antisocial for developing economies reliant on resource growth for vital infrastructure.

To effectively implement the CE as a tool for SD, addressing challenges is crucial. This involves reconciling conflicts between "top-down" and "bottom-up" approaches, clarifying the alignment between micro-level CE and macro-level SD, and resolving conflicting motivations among stakeholders. Enhancing collaboration, providing comprehensive global overviews, and establishing a clear vision for CE implementation are vital steps toward ensuring success. Despite the introduction of tools for sustainable purposes, the overarching objective of the CE remains uncertain, and the potential extra costs associated with implementation need careful consideration in the pursuit of SD.

VII. Results and Discussion

The potential of the CE to foster economic growth while concurrently safeguarding the natural environment and enhancing social equity for current and future generations remains uncertain, challenging the validity of this assertion.

Undeniably both SD and the CE rely on the decoupling of resource exploitation from economic growth. Although the SD concept prioritizes people, emphasizing economic prosperity as a path to fulfilling lives in harmony with nature, the CE remains focused on technological solutions, the implementation of which is driven by a promise of traditional economic growth [17].

To view the CE as a tool to accomplish sustainability, the full integration of the CE with SD is crucial. This requires a comprehensive reassessment of the CE, expanding its focus beyond closed-loop recycling and immediate economic benefits. Instead, the shift should be towards a transformed economy that strategically manages resource access to uphold or enhance social well-being and environmental quality.

The concept of the CE should address inquiries such as whether it is possible for individuals to genuinely replenish natural capital, especially critical natural capital, while promoting high quality of life and well-being. Determining the size of our resource economy without depleting natural capital and the planet's absorptive capacity, as well as evaluating the resource intensity of a service-based economy, are also essential questions to be considered.

The CE concept should be transformed towards regenerative socio-economic structures that align with the Earth's system boundaries. This transformation can address the CE's current shortcomings, particularly its insufficient consideration of the social dimension and the need for system-wide thinking regarding entropy and biophysical limits [38], [69], [70], [71].

The CE should focus on a set of environmental, social and economic values, in which the economy becomes a means to reorganize society and the environment and not an end in itself [17].

The model of the Doughnut Economics (DE) developed by Kate Raworth [72] was proposed as a framework for the enhancement of the CE concept, providing a comprehensive and integrated approach that incorporates not only the efficient use of resources but also a strong emphasis on social equity, justice, and environmental sustainability. The model of the DE shows the minimum and maximum limits that humanity must respect in order to develop [72] (see Fig. 4).

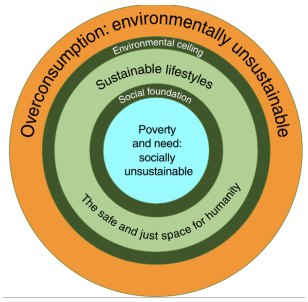

Fig. 4. Simplified version of the doughnut: a safe space within social and environmental limits [72]

The inner ring of the doughnut represents the social foundation (basic needs that everyone should have access to), the outer ring of the doughnut represents the ecological ceiling (planetary boundaries), between social and planetary boundaries lies an environmentally safe and socially just space in which humanity can thrive [72].

By aligning the principles of the DE with CE practices, it is possible to create an economic system that operates within a safe and just space for humanity, simultaneously meeting the essential needs of all individuals while respecting the ecological boundaries of the planet. This collaborative integration seeks to foster a regenerative and equitable economic paradigm, reinforcing the broader vision of SD and responsible resource management. DE mainly focuses on rethinking the purpose and goals of economic activity by applying holistic and systemic thinking to various domains and scales. It is a conceptual and normative model that offers a vision and a direction for achieving social justice and an ecological balance.

Friant et al. [15] classify the DE as one of a set of new holistic circularity views. In recent decades, the original concept of the CE has constantly developed and transformed, absorbing new holistic and transformational views on circularity such as the Blue Economy [73], the DE [72], the Spiral Economy [74], Transition Degrowth [75], Post-growth [76], the Permacircular Economy [77], etc. Limited attention has been given to transformational views of circularity and alternative concepts from the Global South, such as "ubuntu" [78], "ecological swaraj" [79], and the "Buddhist middle path" [80], which emphasize values and principles that promote a sustainable and harmonious relationship between humanity and the environment [15].

Friant et al. [15] identify two overarching trends within the CE concept: the first involves reformist discourses operating within the boundaries of the capitalist system, while the second encompasses transformational discourses aiming for a comprehensive overhaul of the socio-economic structure. Both types of discourse address concerns related to planetary boundaries, the rebound effect, social justice, and good governance. However, they differ in their perspectives on the ability of capitalism to surpass resource constraints and separate ecological degradation from economic growth. The term **circular society** is proposed to distinguish discourses that go beyond market-based solutions and economic considerations and **view circularity as a holistic social transformation** (see Fig. 5).

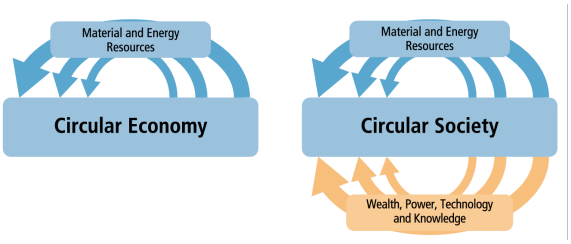

Fig. 5. Conceptual differentiation between the Circular Economy and a Circular Society [15]

According to Fig. 5, a circular society encompasses discourses with a vision of circularity where not only resources circulate in sustainable loops but also wealth, knowledge, technology, and power are circulated and redistributed throughout the society. These discourses, therefore, inclusively **embrace the three pillars of sustainability and perceive circularity as an all-encompassing transition, addressing issues of political empowerment and social justice**. In contrast, the CE concept primarily focuses on the circulation of resources, predominantly dealing with circularity through a technical lens of ecological and material efficiency alone [15].

VIII. Conclusions

The current concept and application of the CE does not fully cover all aspects of sustainability, as it may focus mainly on resource efficiency or waste reduction but may not sufficiently consider social issues. The SD framework establishes goals to be achieved to solve the problems and their consequences, whereas the CE is a tool to address some of the causes of these problems.

It can be concluded that the concept and definition of the CE are anticipated to undergo continuous transformation. It is acknowledged that all current attempts to define the CE merely serve to illustrate the present state of the academic field's understanding of this concept.

The concept of the CE should be viewed through the framework of SD, recognizing the synergy between economic practices, social well-being, and environmental conservation. This synergy would further enhance the holistic approach to achieving lasting global sustainability goals by addressing resource efficiency, social equity, and environmental stewardship within a unified framework.

Within the broad views of CE conceptualizations and adaptations, the overarching concept of **the Sustainable Circular Economy** emerges as a unifying umbrella concept. It synthesizes the multifaceted dimensions of circularity, encapsulating not only resource efficiency and closed-loop systems but also incorporating the crucial elements of social responsibility and environmental stewardship. The Sustainable Circular Economy concept signifies a paradigm shift towards a holistic and enduring approach to sustainability, where economic activities are intricately interconnected with the preservation of social well-being and the conservation of the environment.

The Sustainable Circular Economy thus represents a comprehensive evolution that acknowledges the interconnectedness of economic, social, and

environmental factors in the pursuit of a resilient and regenerative global system.

IX. ACKNOWLEDGEMENTS

This research is funded by the Latvian Council of Science, project "Testing Interventions and Developing a Knowledge-based Recommendation System to Reduce Plate Waste in School Catering in Latvia", project No. lzp-2022/1-0492

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