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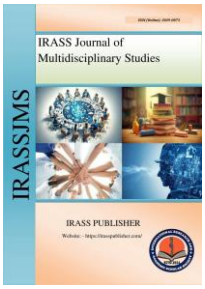

Circular Economy and Sustainability: A Critical Review

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Abstract: Making the shift to a circular economy (CE) is widely recognized as a central pillar for achieving environmental and economic sustainability on a global scale. This review article critically explores theoretical and practical approaches to the circular economy, focusing on their definitions, theoretical underpinnings, barriers, alternative dimensions, and practical recommendations for adoption in national contexts. The analysis is anchored in recent studies that highlight the challenges and opportunities of CE, with an emphasis on its integration into socio-economic and ecological systems.

Keywords: Circular Economy; Linear Economy; Sustainability

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1. Introduction

Global issues like environmental degradation, natural resource depletion, and global warming are caused by the traditional the linear economy is based on the "extract, produce, dispose" model (Ellen MacArthur Foundation, 2020). The circular economy (CE), a creative solution to the environmental crises of waste and degradation, promotes recycling, reuse, and regeneration at every stage of the product life cycle in an effort to "close the loop" on resources (Geissdoerfer et al., 2017).

Despite its origins in economic theories in 1989 (Pearce & Turner, 1989), the CE has recently acquired popularity in relation to the Sustainable Development Goals (SDGs), particularly goal 12 (responsible production and consumption) and goal 13 (climate action),(UNEP, 2022). With an emphasis on structural hurdles, emerging dimensions, prospective solutions, and policies to be adopted, this review the purpose of this essay is to examine how the CE has changed in terms of its definitions., applications, and contemporary issues.

2. Theoretical Foundations and Global Context of the Circular Economy

2.1 The Circular Economy's guiding principles

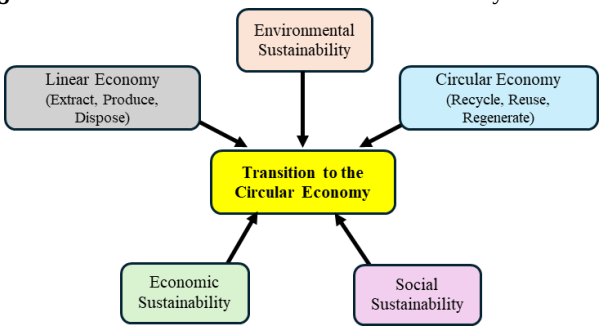
Key tenets of the circular economy include the reduction of waste and pollution, the preservation of materials and products in use, and the restoration of natural systems (Alhawari et al., 2022; Castro et al., 2022; Figge et al., 2023; Kirchherr et al., 2023; Rizos et al., 2017).

Rethinking product and system designs to reduce environmental impacts, restrict waste, and promote reuse is necessary to eradicate waste and pollution (Mostaghimi & Behnamian, 2023; Perey et al., 2018; Stahel, 2019). Incorporating recycling, remanufacturing, or resource sharing techniques into production is the goal of the maintenance of old products and materials (Awan et al., 2021; Geng et al., 2019; Pires & Martinho, 2019; Samadhiya et al., 2023; Sarkar et al., 2022).

To sum up, the goal of regenerating natural systems is to create cycles that follow natural ecological processes and replace finite resources with renewable ones (Araujo-Morera et al., 2021; Bressanelli et al., 2022; Geissdoerfer et al., 2017; Johansen et al., 2022; Morseletto, 2020).

These concepts serve as the foundation for the development and implementation of CE initiatives at the national, sectoral, and social levels. The accompanying figure illustrates the transition from a linear economy to a circular economy.

***Figure 1*:** Transition from Linear to Circular Economy



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2.2 Global Perspectives on the Circular Economy

The adoption of CE varies considerably between countries, reflecting differences in political priorities, economic development, infrastructure and cultural levels (Halog & Anieke, 2021; Marino & Pariso, 2020; Patwa et al., 2021). Developed countries, including

those that comprise the European Union, are at the vanguard of the transition, with comprehensive and pervasive policies (European Commission, 2020). In contrast, emerging countries are confronted with structural challenges but are implementing notable innovations in domains such as waste recycling and renewable energy (Halog & Anieke, 2021; Khan et al., 2023; Khan & Ali, 2022; Mangla et al., 2018; Mishra et al., 2021; Ngan et al., 2019; Schroeder et al., 2019).

Regardless of the socioeconomic environment, CE is commonly linked to shared advantages despite the different circumstances. These include lowering carbon emissions (Hailemariam & Erdiaw-Kwasie, 2023; Mawutor et al., 2023; Wang et al., 2024; Xie et al., 2023; Xiao, 2025), conserving natural resources (Bianchi & Cordella, 2023; Münch et al., 2022; Stahel, 2019; Tambovceva et al., 2021), or generating employment in technological innovation and recycling services (Burger et al., 2019; George et al., 2015; Horbach & Rammer, 2020; Moreno-Mondejar et al., 2021; Potting et al., 2017; Schroeder et al., 2019; UNEP, 2022).

Furthermore, it is believed that the circular economy's effectiveness and economic progress depend heavily on its integration into international trade networks and supply chains (Akbari, 2024; Amir et al., 2023; De Angelis et al., 2018; Govindan & Hasanagic, 2018; Hazen et al., 2021; Meherishi et al., 2019; Sudusinghe & Seuring, 2022). Companies are under pressure to create greener products with less of an impact on the environment and incorporate the principles of the circular economy into their production systems due to the growing consumer demand for eco-friendly products and the growing awareness of sustainability and climate change issues (Camacho-Otero et al., 2018; Hazen et al., 2017; Islam et al., 2021; Patwa et al., 2021; Santos-Conrada et al., 2024; Shevchenko et al., 2023).

2.3 Emerging Dimensions: The Circular Economy in the Context of the Anthropocene

human activity on Earth, the CE is becoming more and more relevant (de Giorge Cerqueira, 2024; Rockström et al., 2024; Rockström et al., 2023; Stahel, 2021). With the aim of reducing the negative consequences of climate change, stopping the irreversible loss of biodiversity, and undoing the substantial harm to the integrity of ocean ecosystems, the CE is considered an essential approach to addressing environmental constraints and determining a sustainable path (Galleno-Schmid et al., 2020; Ghobadi & Sepasgozar, 2023; Romero-Perdomo et al., 2022; Yang et al., 2023).

However, waste management is not the only way that CE is being used in the Anthropocene.. Aspects such as the management and optimization of closed carbon cycles, with the transformation of captured CO_2 into reusable materials (European Commission, 2020; Moreau et al., 2017; Murray et al., 2017; Tan & Lamers, 2021) or the preservation of biodiversity by seeking to reduce resource extraction to protect natural habitats (Isoaho et al., 2024; Plachkov, 2024; Ruokamo et al., 2023) are also relevant.

This perspective serves to reinforce the necessity for the implementation of systemic solutions that are designed to combine circular systems with ecological regeneration (Buckton et al., 2023; Chazdon & Guariguata, 2016; Gibson, 2020; Mang & Reed, 2000).

3. Tools and Technological Innovation

3.1 Economic Instruments

The use of tax and financial incentives has been demonstrated to be an effective means of encouraging practices that align with CE (Aranda-Usón et al., 2019; Domenech & Bahn-Walkowiak, 2019; Heshmati, 2017; Vence & López Pérez, 2021). Several countries have implemented tax reductions for businesses utilising recycled materials, with the objective of fostering the development of a robust market for recycled products (Marino & Pariso, 2020; Milios, 2021; Ren & Albrecht, 2023).

Concurrently, investment funds oriented towards the circular economy are gaining traction in developed economies in regions such as Europe and North America, providing capital for pioneering start-ups within this sector (Agyapong & Tweneboah, 2023; Kumar et al., 2024; Lehmann et al., 2022; Ozili, 2021; Pizi et al., 2021; Smol et al., 2017). These are positive financial mechanisms that encourage companies to adopt environmentally and resource-conscious practices, with the aim of achieving long-term sustainability and profitability, even if this results in a reduction in short-term profit (Akhtar et al., 2022; Barauskaite & Streimikiene, 2021; Gilchrist et al., 2021; Ortiz-de-Mandojana & Bansal, 2016).

3.2 Technological Innovation

Technological innovation plays a pivotal role in the transition to CE (Khan et al., 2022; Suchek et al., 2021). The advent of new technologies, including additive manufacturing with its innovative production methods that facilitate the rapid development of products (3D printing) and blockchain, which enables transparent and secure information sharing over a network, is transforming the traceability of materials and enhancing efficiency in production (Agrawal et al., 2023; Basile et al., 2023; Chauhan et al., 2022; Elghaish et al., 2022; Sassanelli et al., 2023; Schmidt et al., 2024). Blockchain technology has been employed to monitor the life cycle of products, thereby ensuring greater transparency in global supply chains (Esmaeilian et al., 2020; Leng et al., 2020; Liu et al., 2020; Zhang et al., 2020).

4. Barriers and Limitations to Circular Economy

However, this process of changing behavior is fraught with difficulties. These include the high amount of money needed, the fact that consumers do not recognize businesses that use these strategies—either because they are ignorant or have limited resources—or even the fact that the law does not recognize that this is the only way to protect the environment (De Chiara et al., 2024; De Jesus & Mendesça, 2021; Friant et al., 2021; Govindan & Hasanagic, 2018; Grafström & Aasma, 2021; Hart et al., 2019; Hartley et al., 2020; Kirchherr et al., 2018; Salmenperä et al., 2021; Tura et al., 2019).

4.1 Economic barriers

The high initial costs associated with the adoption of circular technologies represent a significant and often limiting obstacle to the implementation of these sustainable strategies (Grafström & Aasma, 2021; Korhonen et al., 2018; Vermunt et al., 2019). This issue is further compounded in developing countries, where companies frequently encounter obstacles in accessing the necessary capital to finance the transition to CE and sustainability (Beheshti et al., 2024; Emodi et al., 2022; Scheel et al., 2020).

Conversely, numerous markets are still devoid of robust and substantial incentives to render circular products competitive with substantially cheaper yet environmentally detrimental linear alternatives (Asgari & Asgari, 2021; Fischer & Pascucci, 2017; Li et al., 2020; Tukker, 2015; Vidal-Ayuso, 2023).

3.2 Cultural Barriers

It is evident that cultural shifts are pivotal for the success of CE. There is a growing consumer preference for companies that align with this strategy (D'Amato, 2021; Shevchenko et al., 2023; Sutcliffe, 2022). Nevertheless, considerable resistance to novel consumption models, such as product sharing, persists in numerous regions (Araujo-Morera et al., 2021; Tuboalabo et al., 2024; Van Loon et al., 2021). Such resistance is frequently ascribed to a dearth of public awareness regarding the advantages of CE and a paucity of consumer sophistication (Kazancoglu et al., 2021; Szilagyi et al., 2022).

4.2 Systemic Barriers

The absence of uniform regulations hinders the implementation of CE by allowing companies to identify alternative avenues where the requisite standards are less stringent (Kirchherr et al., 2018; Mahtre et al., 2023; Mahtre et al., 2021; Rakha, 2023). In countries with decentralized governments or countries with lower levels of development, discrepancies in legislation give rise to inconsistencies that impact the operations of companies in global and increasingly competitive markets (Domenech & Bahn-Walkowiak, 2019; Geissdoerfer et al., 2017).

5. Alternative Dimensions and Critical Perspectives

5.1 Social Equity and the Circular Economy

Although the CE can potentially produce employment by developing a new sector of activity, authors have identified potential issues, including job losses in other sectors and an increased risk of social inequality, particularly in countries where informal waste management work is prevalent (Castro et al., 2022; Mies & Gold, 2021; Padilla-Rivera et al., 2020; Repp et al., 2021; Zisopoulos et al., 2023). It is imperative that countries undergoing a transition to a CE consider the implementation of social inclusion strategies, such as training programs and retraining of workers for activities related to the new sector of activity (Jaeger-Erben et al., 2021; Piao et al., 2023; Souza-Piao et al., 2023; Valencia et al., 2023).

5.2 Circular Economy and Economic Growth

According to George et al. (2015), there is a complex relationship between CE and economic growth. According to a number of studies, CE can boost economic growth by lowering resource exploitation and raising the planet's sustainability level (Hysa et al., 2020; Lakshmi et al., 2024; Naziry et al., 2024; Vîrjan et al., 2023). However, other researchers argue that if the market for circular products is not formed in a way that guarantees their durability and profitability for businesses, the potential economic benefits could be reduced (Corvellec et al., 2022; Kjaer et al., 2019; Yamaka et al., 2022).

6. Recommendations for Future Action

Considering the aforementioned evidence and the existing literature on CE, several recommendations can be put forth to ensure the success of this strategy for sustainability and the protection of the planet. It is imperative to enhance the level of education and awareness about CE. This could entail integrating these topics into the school curriculum (Andrews, 2015; Bugallo-Rodríguez et al., 2020; Que et al., 2020; Wardani et al., 2025). Concurrently, it is imperative to persist and augment economic incentives for enterprises that adopt circular practices, remunerating them for their favourable externalities (Barros et al., 2021; Grafström & Aasma, 2021; Rodríguez-Espíndola et al., 2022; Toșa et al., In 2024, taxes will be levied on linear production practices in order to incorporate the negative externalities they cause (Blomsma et al., 2023; Kazancoglu et al., 2021; Milios, 2021; Vence & López Pérez, 2021). It is imperative that effective monitoring and evaluation systems are developed, including the creation and implementation of national indicators for measuring circular efficiency (De Pascale et al., 2021; Papageorgiou et al., 2021; Rincón-Moreno et al., 2021; Sánchez-Ortiz et al., 2020).

7. Conclusions

CE provides a viable model for pursuing global sustainability, but its implementation necessitates a coordinated effort between countries, companies, and society. This review article aims to assess the barriers, emerging dimensions, and practical ideas that help hasten the shift to circularity. As CE is integrated as an essential component in political, organizational, and social terms in an increasing number of countries, We must make every effort to guarantee that the advantages are shared fairly. Additionally, tactics must inevitably be modified to account for regional differences.

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