

Circular Economy Practices in Manufacturing Sector in Jordan

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Abstract

Circular economy (CE) is a system designed to close resource loops by reducing waste and encouraging material reuse, offering a sustainable alternative to the linear "take-make-dispose" model. The model's applicability in resolving environmental issues and fostering sustainable growth has grown as the advantages of CE are recognized on a global scale. Our research investigates at the context of CE in Jordan, a country dealing with issues such as water scarcity, energy dependence, and waste management. Our Study aims to examines Jordan's current policies and incentives related to CE, particularly in its manufacturing sector. Furthermore, the study identifies barriers to CE adoption, including high cost, limited infrastructure, lack of technology, limited awareness and limited government support, alongside opportunities for growth through government initiatives and national and international partnerships, and education. Widespread CE adoption in Jordan's manufacturing sector provides an opportunity for the country to become a regional and possibly global leader in sustainable practice in the future. Local competitiveness, environmental resilience, and long-term economic growth will also improve. Finally, by observing Jordan's adoption of this practice and comparing Jordan's CE practices to successful regional and global models, we provide policy recommendations for Jordan's context, emphasizing tax incentives, public-private partnerships, and innovation support.

Keywords: Circular Economy (CE), Manufacturing, Sustainability, Waste Management, SDGs, Recycling, Jordan

DOI: 10.7176/JESD/16-1-01

Publication date: January 30th 2025

1. Introduction

In the global arena of economics, companies play an important role in meeting society's demands by producing goods and services based on raw materials. Resources of various types are essential components of the production process, as many industries depend on utilizing these materials to produce products that meet the growing demand from the population need. With the expansion of the global economy and the increasing need for more goods and services for different purposes, whether to achieve self-sufficiency in meeting domestic demand or to cover export demand, production pressures continue to rise, and with them, the waste generated by these products. Waste production adversely impacts the environment in two main ways: it depletes natural resources through unsustainable extraction and diminishes the value of natural capital by introducing pollution (Murray et al., 2017). This necessitates that companies strategically consider how to manage these resources—either by discarding them or by utilizing this waste and recycling it. This is one of the options adopted to reduce production costs, thereby achieving a more efficient and effective product. Cost reductions seen through circular economics are compelling, with vast resource efficiency gains claimed through the adoption of sustainable production practices (Predeville et al., 2014).

Historically, the global economy has operated in a linear (or traditional) model where raw materials are extracted, goods produced and eventually disposed of. This process (commonly known as the take-make-dispose model) poses significant challenges; however, with growth of environmental and social awareness, many are questioning sustainability of such practices. Although some claim that these methods are effective and practical, it is increasingly clear that they are not sustainable. A Linear Economy (LE) is defined as converting natural resources into waste through the process of production. (Murray et al., 2017). Moreover, LE is a traditional system that has been used for a long time, but it does not provide a driving force for sustainable development. Furthermore, LE rarely discusses regaining value from a product's end-of-life cycle (Sharma et al., 2021). In light of these issues, the circular economy (CE) has become known as a transformative model to promote sustainability and reduce waste. There is a growing viewpoint that the only way forward for sustainable production and development is to transition from the current "linear" industrial model to the CE, which would

contribute to building a more environmentally responsible society and a vision of an equal society (Kumar et al., 2019).

As nations prioritize achieving the Sustainable Development Goals (SDGs), the CE emerges as a promising avenue for countries like Jordan, which faces a number of environmental and economic challenges. For instance, Jordan suffers from water scarcity, and under the concept of a “circular economy,” efforts should be made to reduce water usage by recycling it, using water injection with filtration, and enforcing regulations that penalize those who overuse or pollute the water (Eneng et al., 2018). Furthermore, CE will reduce the problems of severe dependence on energy imports and insufficient waste management infrastructure. “Turning waste into energy can be one key to a circular economy enabling the value of products, materials, and resources to be maintained on the market for as long as possible, minimizing waste and resource use” (Malinauskaite et al., 2017). Issues of this nature make the adoption of CE practices not only relevant, but also essential. Jordan has the potential to address several of its most pressing challenges by implementing a circular economy, all while promoting economic growth and improving environmental stewardship. A genuine CE would usher in innovative ideas concerning systems, economics, value creation and consumption; this ultimately fosters sustainable development throughout economy, environment and society (Murray et al., 2017).

This paper seeks to explore the role of CE in Jordan’s manufacturing sector, with a focus on key industries such as textiles, pharmaceuticals, and food processing. It will examine the current integration of CE practices, analyze the challenges and opportunities, and provide a comparative perspective to understand how Jordan can learn from international models. Ultimately, this research aims to offer policy recommendations that can help Jordan transition towards a more sustainable and resilient economic model.

2. Overview of Circular Economy

In 1990, the term “circular economy” was first introduced in the book authored by the British environmental economists David W. Pearce and R. Kerry Turner, *Economics of Natural Resources and the Environment*. The authors highlighted that, at that time, society had not properly directed efforts to address the waste generated by the increasingly diverse consumption of products (Galvão et al., 2018). Additionally, they pointed out that the traditional open-ended economy had been developed without an inherent tendency for recycling, which was reflected in treating the environment as a waste reservoir. In this context, they proposed a closed-loop system that contains the circular flow of materials and energy and called the concept the CE (Su et al., 2013). The CE, with its circular flow and its various benefits in production processes, contributes to sustainable production and waste reduction, enabling the decoupling of economic growth and development from the negative impacts of waste and pollution generated by production activities. The CE facilitates the detachment of the nation’s GDP growth from the consumption of natural resources and the ensuing environmental pollution (Tambovceva et al., 2021).

The concept of CE has undergone significant evolution, reflecting the intensifying global emphasis on sustainability and resource efficiency. Numerous scholars (and organizations) have significantly contributed to the evolution of its definition, highlighting elements such as waste reduction, resource regeneration and closed-loop systems. Table 1 provides some of key CE definitions from different perspectives.

Table 1 provides a selection of definitions from previous studies on the concept of the circular economy (CE). Researchers provided definitions based on a variety of criteria, including origins, principles, and models. Though each definition presents its own unique perspective, several recurring themes arise. Numerous definitions highlight the importance of resource optimization through reduction, reuse, and recycling, aiming to create closed material loops within economic systems. This process is often portrayed as key to achieving sustainability by aligning economic activities with environmental preservation, as seen in the definitions of (Geng and Doberstein, 2008; Kirchherr et al., 2017; Moraga et al., 2019; Jun and Xiangand, 2011; and Kumar et al., 2019). In practice, achieving a fully closed-loop system may necessitate a limited use of virgin resources to supplement recycling and optimization efforts (Figge et al., 2023). A notable recurring theme is the shift from a linear “take-make-waste” system to one that focuses on restorative and regenerative principles, where waste is minimized through innovative business models and design strategies (MacArthur, 2013; Berndtsson, 2015; and Dulia et al., 2021).

In contrast to the LE, which assumes a one-way flow of resources that results in waste, the CE envisions a continuous loop in which materials are consistently reintroduced into production and consumption cycles. The term CE has a linguistic meaning as the antonym of an LE (Murray et al. 2017). A concise definition derived

from Table 1 could be: The CE is a system designed to close resource loops by reducing waste and encouraging material reuse. Figure 1 visually represents the difference between LE and CE, illustrating how the CE system seeks to continuously transform resource flows and reduce waste.

The CE relies on three core principles: reducing, reusing, and recycling. Unlike the LE model, which ends up with waste accumulation, the circular approach focuses on reducing resource use, extending product life cycles, and creating closed-loop systems where materials are continually recycled, forming a continuous cycle in the production process. This model has gained global significance due to its potential to address urgent issues such as climate change, resource scarcity, and environmental pollution. Countries in various parts of the world, especially developed countries in Europe and Asia, are adopting CE practices to promote sustainable growth and as a solution to environmental problems. Examples of countries that have adopted CE, with varying practices due to different cultural, political, and social backgrounds, include the US, UK, European Union nations, South Korea, Japan, and China (Ngan et al., 2019). Speaking of China, it is considered one of the first countries to adopt the concept of the CE as part of its national development strategy since 2002 (Ngan et al., 2019).

When examining human consumption within a LE, we see that it is managed in ways that harm both the environment and human health. Over the past two decades, global material consumption has risen by more than 65%, reaching 95.1 billion metric tons in 2019. In that same year, the amount of electronic waste reached 7.3 kilograms per capita. Additionally, an estimated 13% of food intended for human consumption was lost post-harvest, while an additional 17% was wasted at the food service, retail levels, and household (UNDP, 2023). Furthermore, according to UNDP (2023), the extraction and use of materials accounts for up to 70 percent of global greenhouse gas emissions. Given such a high percentage, everyone will be looking for solutions.

The global importance of the CE is based on its significant environmental impact, as countries have begun to compete in their use of recycled materials. According to the European Environment Agency (2024), In 2022, Europe consumed a higher proportion of recycled materials than other world regions with a circularity rate of 11.5% and aims to increase this rate in the future. The potential of the CE represents a vital approach in global efforts to minimize resource extraction and waste. As countries increasingly adopt CE practices, the shift from linear models to sustainable cycles promises to drive significant improvements in environmental and economic resilience.

3. Context of Jordan

Jordan, a country in the Middle East region, has an area of 89,210 km². Despite its small size, Jordan's climate features long, hot, dry summers and wet, cold winters. Temperatures increase toward the south, with some exceptions in the southern highlands. Precipitation varies significantly by area, largely influenced by the country's diverse topography, giving it a uniqueness compared to other countries (Al-Kharabsheh, 2020). However, Jordan is one of the countries with the scarcest renewable water resources per capita in the world (Al-Kharabsheh, 2020). In 2017, Jordan was classified as the second-poorest country, with only 100 m³ of water per capita per year (Al-Addous et al., 2023). However, with population growth, the municipal water supply in Jordan has steadily increased from 9,244,742 to 12,633,789 cubic meters between 2011 and 2023, with per capita daily consumption rising from 144 to 150 liters (AlShamaen et al., 2024).

Building on Jordan's unique climate and pressing water scarcity challenges, the country also grapples with a broader set of interconnected environmental and economic issues that threaten the sustainability of its natural resources. Consumption rates and resource depletion have increased in light of water scarcity, adding significant pressure on the ecosystem. The significant challenges related to water scarcity in Jordan are the overexploitation of groundwater, rise in water demand, and wasteful practices (Al-Addous et al., 2023). The rise in water demand, contrasted with declining availability, highlights challenges in water management, causing scarcity and sustainability concerns (AlShamaen et al., 2024). Moreover, the country suffers from air pollution, deterioration of soil and water quality due to urban expansion and industrial growth, negatively impacting public health and increasing the economic burden on Jordanian society. According to Shbaita and Gücel (2022), Rapid population growth, urban expansion, the economic crisis, and industrialization in Jordan are significant contributing factors to the depletion of natural resources and the exacerbation of environmental issues.

Amid these challenges, Jordan's renewable energy resources, particularly solar and wind, offer promising opportunities for sustainable development. Jordan is distinguished by its abundance of solar energy, which is the first choice for use and securing various energy needs. It has approximately 320 sunny days and high radiation power rates. Next in line is wind energy, which is also extensively accessible and utilized for energy production in Jordan (Alrwashdeh, 2022). However, there are additional challenges related to energy, which is a

fundamental component in product creation. Jordan largely relies on imports, with about 95% of its total energy generation needs met by imported oil from neighboring countries (Alrwashdeh, 2022). The concerning aspect is that energy demand in Jordan is increasing annually, with an annual growth rate of 5%. In some years, this demand has increased even further, such as in 2019, when energy needs rose by 8.5% compared to the previous year (Alrwashdeh, 2022). The worrying factor in Jordan's growing energy needs is that this continuous growth contradicts the principles of the CE, which aims to reduce dependence on imported resources and recycle local resources. If this increase continues without a shift towards sustainable energy sources or improved energy use efficiency, dependency on imports could deepen, affecting the gross domestic product and, in turn, the entire economy, in addition to its environmental impact.

Regarding environmental issues, countries around the world, including Jordan, countries have recognized that traditional solid waste management practices have not met sustainable development goals. Jordan faces significant challenges in solid waste management, producing around 3,700 tons of municipal waste daily, most of which ends up in one of the country's 24 landfill sites, creating ongoing environmental pressures (Aldayyat et al., 2019). Municipal solid waste generation has increased from 1.5 million tons annually in 2000 to approximately 2.6 million tons per year in 2015. Rapid urban expansion and a high population growth rate are among the main reasons why municipal solid waste has become a critical issue (Hemidat, 2019). One key factor driving urban expansion in Jordan is the regional circumstances that have led to a large influx of refugees. The country, with a population of 11 million, has hosted over 1.3 million Syrian refugees (approximately 12% of the population), placing additional pressure on its already limited natural resources (World Bank, 2024). In a study conducted by Hemidat (2019), he examined the challenges facing the waste management system in Jordan and identified nine main points: lack of legislation, lack of financing, lack of training, inappropriate technologies, lack of availability of primary data on per capita waste generation, inadequate data on waste characteristics, influence of informal sectors, lack of good governance, and civil society inactivity.

However, Jordan's environmental laws and policies seek to regulate waste and recycling and stimulate a sustainable economy, but there are challenges to their effective implementation. Until 2020, Jordan lacked specific regulations for managing solid waste in urban and rural areas (Hemidat et al., 2022). That year, parliament introduced the Waste Management Framework Law, highlighting five key principles: prevention, precaution, extended producer responsibility, polluter pays, and proximity. This followed the National Solid Waste Management Strategy, which aimed to transition from a disposal-focused system to a sustainable, integrated approach based on reduction, reuse, and recycling (Hemidat et al., 2022). Waste management and recycling are essential parts of policies, but they suffer from a lack of resources and infrastructure to support them. Moreover, Despite Jordan's numerous environmental protection laws and regulations, there is an urgent need for comprehensive solid waste management legislation and a national solid waste strategy. (Hajar et al., 2020). On the other hand, industrial policies lack sufficient implementation to integrate CE principles. However, there is a growing trend towards adopting policies that stimulate sustainable industrial innovation, which contributes to reducing dependence on natural resources and reducing waste. For instance, the Ministry of Industry, Trade, and Supply introduced the 2024-2028 Industrial Policy Document, which prioritizes five key industries—food, pharmaceuticals, garments, chemicals, and engineering—as outlined in the Economic Modernization Vision. The policy vision aims for a more integrated Jordanian industry, producing high-value goods, creating inclusive jobs, and accelerating sustainable production (Ministry of Industry, Trade and Supply, 2024).

4. Manufacturing Sector in Jordan

The manufacturing sector in Jordan is a vital sector that contributes significantly to the national economy. The manufacturing sector is also a major player, contributing about 17.9% of the GDP in 2022, reflecting its significant role in the economy compared to other sectors alone (Ministry of Finance, 2023). Approximately 20% of the total workforce in Jordan is employed in this sector, making it a significant contributor to job creation (JSF, 2022). The industrial sector has been further classified into ten subsectors by a decision from the Council of Ministers, as shown in Figure 2.

Jordan's industrial sector holds a key role in the national economy, enjoying several competitive advantages related to relatively high production quality and the availability of raw materials for certain industries (JSF, 2022). However, its competitive advantage is influenced by the extent of green product implementation. For example, Al-Abdallah and Al-Salim (2021), examined chemical industrial plants within Jordanian QIZs. After analyzing all 219 Jordanian chemical manufacturers, they administered a quantitative five-point Likert scale questionnaire to firms implementing green product activities. Their results showed that 20 firms were utilizing

green product innovation, representing only 9.13% of the total population. Furthermore, Hypothesis testing indicated that green product innovation has a statistically significant positive impact on competitive advantage. Implementing green products, including CE practices, is therefore critical for increasing the sector's sustainability. However, there are still challenges in scaling these practices across a wider range of firms in most sectors.

Within the broader context of Jordan's industrial sector, the food industry faces its own set of significant environmental and sustainability concerns, compounded by a lack of regulatory oversight. Food waste in Jordan is estimated at 93 kg per person each year, amounting to nearly one million metric tonnes — enough to sustain 1.5 million people for a full year (Abed Rabboh et al., 2023). Furthermore, Jordan's food system contributes to almost 30% of the nation's total greenhouse gas (GHG) emissions (Crippa et al., 2021). The largest portion of GHG emissions in Jordan's food system comes from “end of life” stages (food waste and disposal), with total emissions rising from 20.9 MtCO₂eq in 2000 to 36.6 MtCO₂eq by 2019 (Abed Rabboh et al., 2023). Recovering resources from food waste to close the supply chain loop is considered a cornerstone for applying CE principles in the food sector. The composition of organic food waste is 50% (Tamasiga et al., 2022), meaning that half of the waste consists of organic materials, specifically food residues, which represents a significant portion that can be utilized for composting or bioenergy production instead of disposal. Additionally, the recycling rate for waste is 7% (Tamasiga et al., 2022), indicating that only 7% of total waste is recycled, while the remaining percentage is disposed of in potentially less sustainable ways. This is a low rate compared to the average of 10% in the Gulf Cooperation Council (GCC) countries (Shalamai, 2022). These figures highlight the urgent need to improve waste management systems and leverage the CE to enhance environmental sustainability in this sector. However, no single entity has taken a clear lead in recycling, preventing food loss, or managing food waste collecting effectively (Abed Rabboh et al., 2023).

Among Jordan's key industries, the textile sector stands out for its economic contribution, employing approximately 89,900 workers, or around 39% of Jordan's manufacturing workforce (Smagadi and Lamas, 2024). Over the past decade, Jordan's textile industry has grown significantly, establishing itself as a major export sector. Exports have more than doubled from \$1.1 billion in 2012 to over \$2.2 billion in 2022, now comprising 7.7% of the country's manufacturing GDP (Smagadi and Lamas, 2024). The textile industry currently lacks the implementation of CE practices in waste management. Incineration and the use of textile waste as energy are last-resort solutions that do not align with this sustainable approach. However, there are efforts by some entities to transition towards a CE approach in their operations. For instance, Lafarge, a cement manufacturer in Jordan, is considering a pilot project similar to one conducted in Egypt, where textile waste is used as an energy source in cement production (GIZ, 2024). If implemented, this initiative would be an effective step toward reinforcing the role of the CE in this sector.

Circular economy practices can support Jordan's efforts toward sustainability in various industries, including, for instance, the pharmaceutical sector. Jordanian pharmaceutical manufacturing companies have integrated certain eco-friendly practices, notably by engaging in green purchasing and promoting environmentally conscious selling strategies. However, there remains a gap in fully adopting sustainable processes within their core operations, where green practices are not as strongly implemented (Sharabati, 2021). Furthermore, Implementing CE principles in an industry like pharmaceuticals is crucial, given the significant environmental impact of its waste. AlBrakat et al. (2023) concluded that managers and decision-makers in pharmaceutical organizations should establish policies outlining the organization's commitment to sustainability and defining its goals and objectives to reduce its environmental impact. Al Smadi et al. (2023) assessed how well Jordan's pharmaceutical waste generators at manufacturing and health service facilities comply with regulatory frameworks through semi-structured interviews. The study revealed a lack of clear, specific regulations for managing pharmaceutical waste, with overlapping jurisdiction among authorities and minimal coordination across regulations. Moreover, observations from site visits showed that current disposal practices are insufficient in effectively reducing the environmental risks associated with pharmaceutical waste.

The primary role of the CE is to minimize waste and mitigate its environmental impact. However, the adoption of CE practices by companies across different sectors appears to be limited, suggesting that the approach has not yet been fully embraced on a practical level. "Sustainability awareness is quite low, and Jordanian companies mostly do not seem to consider the environmental impacts of their manufacturing operations"(Alzubi and Akkerman, 2022). Even the government has not given sufficient attention to implementing CE practices. For example, Al-Sharif et al. (2024) attempted to bridge the knowledge gap regarding the feasibility of recycling concrete in Jordan's CE framework. Their findings revealed that the Jordanian government largely ignores concrete waste, highlighting the critical need for improved waste management strategies, particularly concrete

recycling.

5. Challenges and opportunities

The implementation of the CE faces several challenges in Jordan's manufacturing sector; Figure 3 illustrates these challenges.

Firstly, there is limited awareness about the benefits and principles of CE practices. For example, in research conducted to evaluate recycling awareness in Jordan, researchers concluded that because of the lack of appropriate disposal programs across the country, most respondents do not know where and how to recycle (Almadhi et al., 2023). In Jordan, recycling has yet to be officially implemented, and municipal solid waste is collected as mixed waste with no efforts to separate materials at the source (Hemidat et al., 2022). Another major challenge is the high costs of implementing these practices, including the investment in sustainable processes, present a significant barrier. For example, primary barriers to green supply chain management initiatives in Jordan include high costs, lack of government support, and pressure to reduce selling prices (Sharabati, 2021). It is noteworthy that in the context of the CE, green supply chain management is considered a tool for enhancing resource efficiency and is viewed as a solution to address environmental issues and consumption patterns throughout the entire supply chain (Kazancoglu et al., 2018). Additionally, a lack of adequate infrastructure to support circular systems, such as recycling and waste management facilities, further impedes progress. Without proper infrastructure, efforts toward recycling and waste management cannot be fully realized. Moreover, the lack of advanced technology complicates the development of innovative solutions for waste reduction and resource recovery, both in large industries and even in small and medium-sized enterprises (SMEs). In the context of SMEs, they represent 95% of all registered companies and contribute more than half of Jordan's GDP (Almasri and Ying, 2024). Furthermore, these companies are known for their ideal flexibility to adopt advanced technologies to enhance the CE. However, all these industries face significant challenges in adopting technology due to limited resources and a lack of technological infrastructure (Almasri and Ying, 2024). Finally, the lack of government support for industries to encourage CE practices and the optimal use of resources remains a critical barrier to the widespread adoption of CE principles. Hence, opportunities for developing the CE exist, as illustrated in Figure 4.

In addition to the challenges, there are opportunities that will help foster and develop the CE in Jordanian industries. Firstly, government initiatives —while there may be limited government support in some areas— are aimed at staying aligned with the times and achieving SDGs. The government's significant role is centered on providing facilitations, regulations, and policies that promote CE practices across various sectors in the Kingdom. The government is critical in developing and enforcing a regulatory framework that encourages sustainable practices. This entails establishing recycling regulations, such as providing subsidies and tax incentives to companies that invest in Jordanian recycling facilities (Al-Sharif et al., 2024). Secondly, working on educating people and raising their awareness, whether through educational institutions for different age groups or through field education for various organizations and industries, on how to implement practices that reduce environmental problems and enhance circularity. A study of five major towns and 69 villages in southern Jordan to assess the major factors contributing to people's environmental awareness discovered that increasing education raises awareness of environmental issues such as air and solid waste management (Ziadat, 2010). Thirdly, strengthening local and international partnerships is essential to promote CE practices. These partnerships can facilitate the exchange of knowledge, technologies, and resources, in addition to their important role in aligning Jordan's efforts with the achievement of the SDGs. Tamasiga et al. (2022), emphasized the urgent need for governments, the private sector, educational institutions, and researchers to collaborate to promote, integrate, and accelerate the adoption of circularity.

6. Comparative Analysis

Comparing countries based on specific rates is primarily concerned with classification and improvement. For example, comparing circular practices in Jordan at the regional or even international level would provide valuable insights into what Jordan can learn from other countries that have implemented circular practices in a variety of industries. This would allow Jordan to use one of these models to develop or implement CE practices in its own local context. Table 2 presents the recent comparative scores, including the Environmental Performance Index (EPI) Waste Recovery Rate (2024 Score) and the EPI Recycling (2022 Score). The Recycling Score and Waste Recovery Score are both indicators of a country's CE performance, but they measure different aspects of waste management. These data highlight Jordan's current standing relative to major global economies

and neighboring countries.

Switzerland stands out with an impressive EPI Waste Recovery Score of 100, indicating that it recovers all of its waste. Finland and Denmark are close behind, with nearly identical high scores, indicating strong CE practices in both countries. Interestingly, despite being one of the world's most powerful industrial nations, China has a low EPI Waste Recovery Score of 4.5. South Korea leads in recycling with an impressive EPI Recycling Score of 67.1, demonstrating its advanced recycling systems and commitment to waste reduction.

Jordan's waste recovery score ranks 72nd globally, standing at just 6.2. Its recycling score is also low, ranking 106th with a score of 14.6, placing it far behind global leaders like Switzerland and South Korea, as well as neighboring countries such as Egypt and Lebanon. The gap highlights the need for stronger policies and infrastructure to encourage CE practices in Jordan. It can gain valuable insights into how to improve its CE practices by examining the top-performing countries in the region and around the world, as well as their action plans.

7. Discussion

Jordan's CE performance, as evidenced by its low EPI Waste Recovery and Recycling scores compared to global and regional averages, highlights substantial gaps and challenges in waste management and resource recovery. Based on previous observations when looking at Jordanian industries, there is still a weakness in adopting green practices in general and the CE in particular. Alzubi and Akkerman (2022) evaluated the situation of Jordanian manufacturing companies in terms of voluntarily adopting sustainable development practices versus doing so under external pressure. Their findings indicated that Jordanian manufacturers should take additional steps to adopt sustainability in order to compete in international markets. Furthermore, To increase multinational companies' investment potential, Jordan should take advantage of industrial parks and implement regulations that require manufacturers to adopt sustainability practices under external pressure. However, its implementation can be challenging; there are various factors to consider. These include limited awareness of CE principles, high costs associated with adopting CE practices, a lack of infrastructure, and limited government incentives for circular initiatives. Although the concept of CE is gradually gaining recognition, various obstacles prevent effective implementation. This model promotes resource efficiency and waste reduction, but it requires a shift in mindset (Arruda et al., 2021). For example, Saidan (2019) investigated the generation of industrial waste in Jordan to determine its potential for recycling. The study revealed a lack of effective waste recycling practices in the surveyed industries, bringing attention to the need for improvement in the recycling of waste.

When comparing Jordan's performance to that of advanced economies like Switzerland and South Korea, which lead in waste recovery and recycling, the need for a strong strategy in Jordan becomes evident. Switzerland's exemplary waste recovery score serves as a model for comprehensive recycling practices supported by advanced infrastructure. Similarly, South Korea's high recycling score underscores the importance of efficient recycling systems and public participation. Closer to home, neighboring countries such as Egypt and Lebanon, despite facing some of the same structural challenges, have made notable progress in recycling. This gap between Jordan and the leading nations, and lower scores compared to neighboring countries, points to the need for systematic improvements, particularly in areas of policy support, technological innovation, and educational efforts, which are key opportunities to enhance recycling practices. However, although many are aware of its importance, not everyone is ready to actively embrace and implement these practices and so the shift may take time and effort (Arruda et al., 2021).

While our study defined the term of CE in the context of Jordan and its industries, despite the significant challenges facing Jordan, it also has opportunities to develop its CE principles. In light of this, the CE emerges as an effective tool for triggering a sustainable development process (Arruda et al., 2021). There are many studies that emphasize the importance of Jordan adopting green practices. All industrial sectors, regardless of their size, have an impact when adopting a sustainable tool. Many Studies have recommended that the industry adopt sustainability tools to reduce waste and pollution. For instance, Al-Awamleh et al. (2022), recommended that pharmaceutical companies in Jordan must take initiatives green and the trend towards implementing a green supply chain approach that reduces the consumption of non-renewable resources and waste, and to establish special laws and regulations in the company that oblige employees to apply the green approach in their practices within the work. Furthermore, "The owners and managers of Jordanian pharmaceutical manufacturing organizations must focus more on green operations, especially using recycled raw material, renewable energy, pollution, green packaging, production waste, and employees' health and safety" (Sharabati, 2021). Moreover, Initiatives such as Building public awareness and embedding CE principles into educational curricula and industry practices can further support this transition. Raising public awareness is a critical step in increasing the

percentage of recycling rates (Almadhi et al., 2023). With strategic focus, Jordan has the potential to enhance its waste recovery and recycling rates, advancing its sustainability efforts and bolstering its position as a regional leader in the CE. However, while strategic focus and initiatives such as public awareness and educational reforms can help Jordan's CE transition, biophysical constraints may limit the country's ability to fully implement green practices. These constraints include the high energy requirements associated with resource recovery and the quality losses that occur during the recycling process. Additionally, there is a continued demand for virgin resource extraction and materials containing organic and inorganic elements, either by their nature or design, which further complicates the transition to a fully circular system (Velenturf et al., 2019). Addressing these constraints, along with organizational efforts, will be critical to achieving long-term improvements.

Finally, the transition from LE to CE in a closed-loop system may take a gradual, upward direction. Circular economy practices are likely to spread gradually across all sectors in Jordan, not just the industrial sector, as plans and regulations to support their adoption are developed. Notably, this approach can be used in a variety of sectors, regardless of type. In line with the concept of "closing the loop," the circular economy can extend across various sectors, including the wastewater treatment industry (Guerra-Rodríguez et al., 2020).

8. Conclusion and Policy Recommendations

8.1. Conclusion

In conclusion, the shift from a LE to a CE offers Jordan a significant opportunity to enhance sustainability across various sectors. Promoting CE practices on a wider scale in various industries in Jordan would increase economic resilience and with the country aligning by promoting these practices that are consistent with the SDGs, there is an opportunity to become a leading country in the region in adopting circular practices that increase the benefits of waste reduction. Furthermore, By facing obstacles and implementing opportunities in the long term, there will be a positive impact on economic, environmental, social, and even cultural levels. Currently, the adoption of eco-friendly practices, particularly CE, remains low. Additionally, there is an opportunity to learn from successful CE models in high-performing countries and apply them in Jordan to capture those benefits in sectors. The key is to demonstrate a genuine commitment to adopting these practices through practical implementation on the ground. Jordan could become a regional leader in CE practices with continued commitment, generating favorable environmental effects and establishing a clear path for the future.

8.2. Policy Recommendations

To enhance the CE in Jordan, It is essential to establish policies and define a clear future vision for practical implementation on the ground. The following are practical recommendations that may help realize this vision:

- (1) Tax incentives: Providing tax exemptions and incentives for sectors adopting circular practices, such as recycling or waste recovery. These incentives can vary in their percentage depending on the importance and impact of the industry. Additionally, they encourage industries to invest in sustainable processes and help alleviate the initial costs associated with transitioning to circular models.
- (2) Innovation support: Establishing funds or grants to support and encourage research and development, as well as innovation in circular technologies, sustainable product design, and renewable energy. This can help foster a culture of innovation and encourage both startups and established companies to explore more sustainable solutions.
- (3) Public-private partnerships: To ensure that circular practices align with national and industry-specific priorities, efforts should also be made to strengthen partnerships between the public and private sectors to drive the development and implementation of joint projects for circular economy applications. These efforts can increase resource sharing and enable the exchange of knowledge and expertise.
- (4) Overcoming Obstacles and Leveraging Opportunities: By developing targeted strategies to address current obstacles (such as limited infrastructure, costs, etc.) while taking advantage of Jordan's available resources and adopting a successful model from one of the leading countries in implementing this model in the future to maximize circular practices.

These recommendations can lay the foundation for a more sustainable and resilient economy and industries in Jordan by promoting circular practices that, in turn, reduce traditional practices and enhance various environmental benefits.

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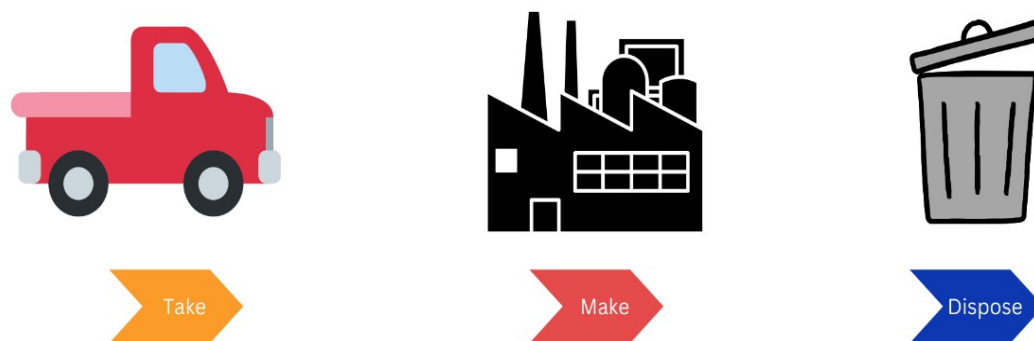
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Table 1. Some of the Circular economy (CE) Definitions.

Definitions	Literature Source	Year
The CE model refers to the realization of a closed loop of material flows within an economic system. Its successful implementation is viewed as a means for countries to leapfrog the environmental damage often associated with industrialization.	Geng & Doberstein	2008
The CE is a new form of economic development that reflects the principles of sustainable development. It is becoming a primary development strategy in many regions and countries, focusing on reducing, reusing, and recycling activities in production, circulation, and consumption, while rejecting the principles of both natural and traditional economies.	Jun & Xiang	2011
A CE is an industrial system designed to be restorative and regenerative by intention. It replaces the traditional 'end-of-life' concept with restoration, emphasizes the use of renewable energy, eliminates toxic chemicals that hinder reuse, and seeks to eliminate waste through the optimized design of materials, products, systems, and business models.	MacArthur	2013
The CE concept originates from the goal of transforming the linear "take-make-waste" economic system to reduce resource consumption and minimize the waste of natural capital.	Berndtsson	2015
A CE is an economic system based on business models that replace the 'end-of-life' concept by reducing, reusing, recycling, and recovering materials in production, distribution, and consumption. It operates at micro (products, companies, consumers), meso (eco-industrial parks), and macro (city, region, nation) levels to achieve sustainable development by creating environmental quality, economic prosperity, and social equity for present and future generations.	Kirchherr et al.	2017
CE is an approach that promotes the responsible and cyclical use of resources. In recent years, it has been endorsed as a policy aimed at minimizing environmental burdens while stimulating economic growth.	Moraga et al.	2019
CE can be defined as an economic growth and development system that integrates the economy with natural resources and the environment.	Kumar et al.	2019
The CE is restorative and excretes waste with design by more suitable materials, products, and systems design enabled via innovative business models.	Dulia et al.	2021
The CE is a multi-level resource utilization system designed to completely close resource loops. Recycling and resource flow optimization are examples of practices that help to support this system. While the ideal concept envisions completely closed loops, the practical implementation recognizes that some use of virgin resources may still be required.	Figge et al.	2023

Linear Economy (LE)



Circular Economy (CE)

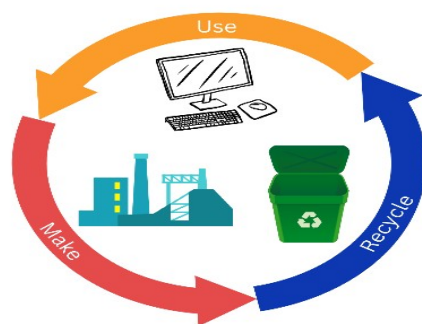


Figure 1. Resource Flow in LE vs. CE

1.Mining industries	Industries and sectors subclassification in Jordan	2. Plastic and rubber industries
3.Construction industries		4.Therapeutics and medical industries
5.Food, supplies, and agriculture industries		6.Leather and garments industries
7.Engineering, electrical industries and IT sector		8.Packaging and paper industries
9.Furniture and wooden industries		10.Chemical and cosmetics industries

Figure 2. Classification of Industrial Subsectors
 Source: [JSF,2022].

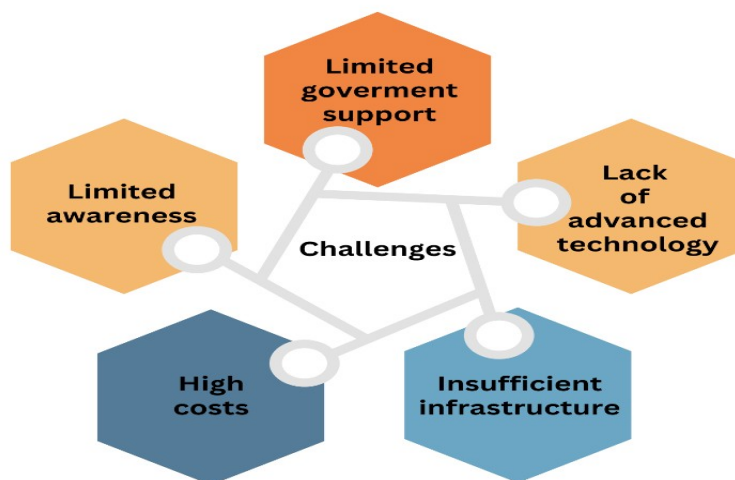


Figure 3. Challenges to CE in Manufacturing

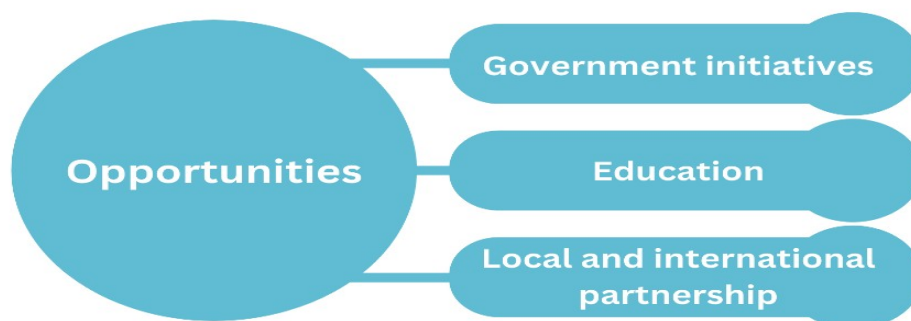


Figure 4. Opportunities for CE Development in Jordanian Industries.

Table.2 Comparative Analysis of CE Performance: EPI Waste Recovery and Recycling Scores.

COUNTRY	EPI WASTE RECOVERY SCORE (2024)	EPI RECYCLING SCORE (2022)
Switzerland	100	30.1
Denmark	99.9	35.4
Finland	99.4	35.4
Sweden	99.2	39.7
Germany	98.9	49.8
Japan	94.4	11.5
UK	85.2	34.2
South Korea	82.0	67.1
France	75.2	31.6
Kuwait	59.6	15.4
USA	44.0	14.8
Bahrain	34.0	14.1
Qatar	23.6	6.0
Lebanon	23.0	15.0
Saudi Arabia	15.0	18.8
Egypt	6.5	26.6
Jordan	6.2	14.6
Iraq	4.8	15.4
China	4.5	24.4

Source: [EPI, 2024]; [EPI, 2022].

Table 2 presents recent comparative scores related to circular economy (CE) performance, including the Environmental Performance Index (EPI) Waste Recovery Rate (2024) and Recycling Score (2022). The data provide insights into Jordan's performance in waste management compared to major global economies and neighboring countries.