Circular Economy and Sustainable Production and Consumption

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Chapter 3
Circular Economy and Sustainable Production and Consumption

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Abstract For a long time, it has been a common, one-way process of using materials taken from the earth and ending up discarding them as waste. The circular economy is primarily concerned with the reduction of waste and pollution, the reuse of products and materials, and the renewal of nature. It is an alternative model of production, consumption, and disposal that is being proposed as a way to address both mounting environmental crises and expanding global prosperity. It is considered a powerful tool for resource conservation and reducing needless environmental exploitation. Efficient and effective output can be guaranteed through the adoption of sustainable consumption and production practices. It safeguards the requirements of future generations while ensuring that human activities do not exceed Earth's carrying capacity. The consumption pattern in an economy determines the growth and success of the economy, which can be improved by switching to reusable products. In this chapter, we have looked at the theoretical foundations of the circular economy and their connections to sustainability as they are currently formulated in the literature. The research also aimed to provide a concise summary of the circular economy, including its background, possibilities, management, business opportunities, and metrics. The chapter discussed the gap between conventional and circular economic systems. Furthermore, the study also discussed the challenges and limitations of the circular economy at the institutional, technical, managerial, and societal levels.

Keywords Linear economy · Natural resources · Recycle · Reduce · Reuse · Waste

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3.1 Introduction

Since the industrial revolution, both the growing global population and demand for natural resources have increased significantly, indicating a rise in natural resource consumption. As a result of such indiscriminate use, there has been a significant depletion of our natural resources, and there has been strong speculation that the resulting environmental damage will exceed the environment's carrying capacity in the near future. Additionally, driven by these factors (urbanization, population bloom, industrialization, and other anthropogenic activities), the rates of global waste generation have been alarming, and by 2050, the world is projected to generate 3.4 billion tons of waste per year, a significant increase from the 2.01 billion tons generated annually at present (Kaza et al. 2018). Environmental issues such as biodiversity loss, air, soil, and water pollution, the depletion of resources, and unsustainable land usage are increasingly threatening the life-support systems of the Earth (Rockstrom et al. 2009). To deal with these problems, the circular economy has gained popularity in recent times. However, there is still a long way to go in order to make the shift from a linear to a circular economy paradigm, which will necessitate the introduction of novel insights that will ultimately result in cutting-edge technology developments that will enable the creation of environmentally friendly goods and services (Abad-Segura et al. 2020).

The idea of a circular model of production is not a new concept. Boulding (1966) described Earth as a "closed spaceship" with limited reservoirs of resources, and humans must discover the significance of being a part of this cyclical ecological system of production. Other possible sources of inspiration for the notion of a circular economy include Rachel Carson's Silent Spring (Carson 1962), the "limits to growth" argument of the Club of Rome (1970), and the work of eco-economist Herman Daly (Naustdalslid 2014). In the year 1990, Pearce and Turner (Pearce and Turner 1990) introduced the concept of a circular economy in their book "Economics of Natural Resources and the Environment," using ideas from the previous studies of Kenneth E. Boulding. It began by looking at the traditional linear economic system and developing a new economic model known as a "circular economy," which was based on the first two laws of thermodynamics. They developed a conceptual framework, such as the source-product-pollution mode of the circular economy. However, it is important to note that the concept of a "circular economy" does not apply to thermodynamics, because no system can be 100% circular (or closed) according to the entropy law (Andersen 2007). Table 3.1 provides a summary of the objectives and conclusions of some noteworthy investigations published to date.

Initially, the 3Rs were the cornerstones of the circular economy idea, which includes reducing, reusing, and recycling (Wu et al. 2014), and later, the 6Rs principle was adopted, which mainly encompasses reusing, reducing, redesigning, recycling, recovering, and remanufacturing (Jawahir and Bradley 2016). Various cultural, social, and political systems influenced the distinct evolution of the notion of a circular economy. In the early 1990s, the circular economy concept

Table 3.1 Highlights of some of the important studies published on circular economy till date

S.No.	Objective of the studies	Conclusions	References
1	To adapt the theoretical circular economy framework in the field of agriculture	The gap between circular economy framework and agriculture sector could be reduced in two ways: (i) by adapting the general circular economy framework to the agricultural sector's specificities; (ii) by evaluating how indicators of agricultural production systems' circularity support decision-making	Velasco-Muñoz et al. (2021)
2	To promote the circular utilization of agricultural resources	Publicity and education should be strengthened to promote the concept of ecological values and green consumption in the whole society like choosing less packaging or recyclable items, rather than a one-time item to minimize waste generation.	Jun and Xiang (2011)
3	To develop a new system of circular economy using traditional linear economic system	Traditional linear system could be used to develop a new circular economy which uses the first two laws of thermodynamics. Developed a new conceptual framework for circular economy, such as the source-product-pollution model. Four economic functions of the environment can be identified: amenity values, resource provision, waste and emission sink, and life-support system	Pearce and Turner (1990)
4	To present a multi-sectorial and macro-meso level framework to monitor (and set goals for) circular economy implementation in cities	Framework encompasses circular economy key concepts, such as flexibility, modularity, and transparency. It is structured to include all sectors in which circular economy could be adopted in a city	Cavaleiro de Ferreira and Fuso-Nerini (2019)
5	To review the history of the circular economy concept to provide a context for a critical examination of how it is applied currently	Circular economy-related initiatives require integrated bottom-up and top-down approaches to implementation and evaluation. Critical research gaps observed in this study include the circular economy concept application to and assessment of the biological systems (e.g., agricultural industries) and the chemical/biochemical industry products and value chains	Winans et al. (2017)
6	To describes a new tool to ensure the quantification of circular initiatives and the method to define it	A new Circular Business Model (CBM) visualization tool, which overcomes the main limitations of the existing models able to explain circular economy concepts but not to boost its practical implementation in industry. Every industry can use CBM to find hidden circular possibilities or choose the optimum circular economy strategy	Bianchini et al. (2019)

(continued)

Table 3.1 (continued)

S.No.	Objective of the studies	Conclusions	References
7	To map methodological developments regarding circularity metrics for products and services	The circular economy is expected to be the optimal pathway to sustainable development. A good circularity metric should measure how circular strategies contribute to sustainable development without shifting the burden from reduced material consumption to increased environmental, economic, or social impacts	Corona et al. (2019)
8	To describe the foundations for establishing a circular in small and medium enterprises in India	The circular economy faces institutional, technical, managerial, and societal challenges	Sohal et al. (2022)
9	To present the principles of sustainable manufacturing to serve as the basis, and to provide the technological elements to ensure the creation of a circular economy	6R-based technological elements, which encompass reusing, reducing, redesigning, recycling, recovering, and remanufacturing are identified and shown as essential ingredients for achieving economic growth, environmental protection, and societal benefits	Jawahir and Bradley (2016)
10	To describe the role of soil and land management in a circular economy	The circular economy is highly dependent on the functioning of soils and land for the production of food and other biomass. Earth diminishing potential for resource production, due to a range of reasons, is leading to resource scarcity. The management of the resources, land, and soil is thus necessary to make a circular economy successful	Breure et al. (2018)

was introduced into German environmental policy with the goal of addressing challenges associated with input materials and natural resource utilization for long-term economic growth (Geng and Doberstein 2008). Since the beginning of the twenty-first century, China has pursued comprehensive circular economy policies, such as resource-oriented, production-oriented, waste-oriented, use-oriented, and life cycle-oriented. In China, the notion of circular economy is utilized as a tool for profitable product creation, the development of new technologies, the updating of equipment, and the improvement of industrial management (Yuan et al. 2006). In the United Kingdom, Denmark, Switzerland, and Portugal, the circular economy concept is mostly applied to waste management, although in certain regions of Korea and Japan, an increase in consumer responsibility for material and waste usage has been seen for its application. In North America and Europe, enhancing 3Rs initiatives (reduce, reuse, and recycle) and conducting product-level life cycle analyses have been the primary motivation behind the application of the circular economy concept (Winans et al. 2017).

3.1.1 Why Circular Economy?

We use materials obtained from the earth and, at last, throw them away as waste—the process is direct. The circular economy mainly focuses on the elimination of waste products, using materials to their full value, and their subsequent renewal. By these methods, it boosts economic growth. The circular economy is the model for sustainable use of nature and its products by eradicating toxic substances from nature. The circular economy focuses on corporate and industrial processes for the natural development of products. It promotes the idea of conserving natural resources by combining science and technology with societal policies. In today's time, circular economies can be understood as a universal system that flows in a circular loop with multiple knots (Cavaleiro de Ferreira and Fuso-Nerini 2019). The circular economy provides structural support to the combined existing methods and plans in a systematic way, which helps in achieving low consumption of resources and low production of pollution with a high circulation rate. Essentially, it promotes the idea of preserving the ecosystem's balance and preserving the environment and natural resources for future generations, so that our children and grandchildren can benefit from the resources provided by nature. The main component of a circular economy is related to the usage of products and the energy flow of the products in an ecosystem. The most important is a closed-loop ecosystem in which waste is nearly zero because every residual created from waste is used for product renewal or to create new products from its segments.

3.2 Principles of Circular Economy

- *Elimination of pollution and waste*: The elimination of waste and pollution is the primary tenet of the circular economy. Because the resources on our planet are limited, a take-make-waste economic system cannot function over the long run. The circular economy paradigm blends scientific principles with natural cycles. Waste that is produced can be recycled with the aid of contemporary technology. Rather than piling up, generated trash should be incorporated into subsequent manufacturing cycles. Companies were able to develop practical circular economy strategies within the industrial ecology framework due to technological advancements, design, and recovery processes (Hobson 2016). This encouraged a decrease in raw material consumption and waste production, which has positive environmental and financial effects for businesses (Andersen 2007).
- *Circulation of products and raw materials at their highest level of values*: Circulating goods and materials at their peak utility value is the circular economy's second tenet. Maintaining materials in use implies using them either as a product or, when that is no longer possible, as components or raw materials. Nothing is wasted in this manner, and materials and goods maintain their inherent value. There are numerous ways to maintain the circulation of goods and resources, and it can be useful to consider two primary cycles: the technological cycle and the biological cycle. In the technological cycle, products are reused, repaired, remanufactured, and recycled, whereas biodegradable materials are returned to the ground in the biological cycle via procedures such as composting and anaerobic digestion.

Prolonging replacement is one method of extending the lifespan of an item when it is owned. Replacement behavior can be influenced by a wide range of elements, including customer attitudes and situational circumstances (Van Nes 2016). This may be caused by product development strategies (layout for repair and upgrade, etc.) or a strong product connection. If a customer returns a used item, allowing the product, parts, or materials to be recirculated, it is one way for businesses to realize value from those products (Wilson et al. 2017). Its highest degree of value is maintained if the object continues to function as a whole. As an alternative, users might sell, generally through a third-party website or a used-goods store. Last but not least, individuals could promote reuse by donating unwanted goods to charities or friends and family or by sharing them on networks. In a circular economy, material recycling is the lowest degree of value preservation, although in specific product categories and situations it might be significant. In these situations, correct disposal and recycling are required. Anaerobic digestion, taking products to a certified recycling facility, or specifically avoiding throwing them in the regular trash can be included in this.

- *Room for nature to thrive*: Increased resource consumption is putting a strain on the environment and depleting its natural resources. Ecosystems are under stress because of human activities, which have detrimental effects on biodiversity and the services ecosystems provide (such as adapting to and mitigating the effects of climate change, degrading pollutants, preventing soil erosion, and increasing soil fertility). Furthermore, the adoption of improper disposal of resource residues in the waste phase of product life can have serious consequences for the environment. Adopting a circular economy, encouraging the efficient use of resources and preventing the production of problematic residue, is in response to the rising environmental stress resulting from different anthropogenic activities such as mineral resource extraction, land use and degradation, the disposal of waste materials, and the scarcity of land and resources (Breure et al. 2018). We must resort to creating natural capital rather than perpetually destroying nature. Therefore, regeneration of nature is the circular economy's third major goal. A circular economy, as opposed to the concept of "take-make-waste" in a linear economy, supports natural processes and creates more space for nature to flourish (Fig. 3.1). By adopting a more circular model for economic activity, we may redirect resources from extraction to renewal. The goal of the circular economy is to completely eliminate waste by reusing and recycling everything possible. Long-term, effective (re)use of resources is central to the circular economy. In this light, the (renewable) biobased materials' utilization as manufacturing elements is considered crucial to the circular economy (De Baan et al. 2013). However, possibilities for applying biobased resources in various ways could lead to increased competition for scarce land.

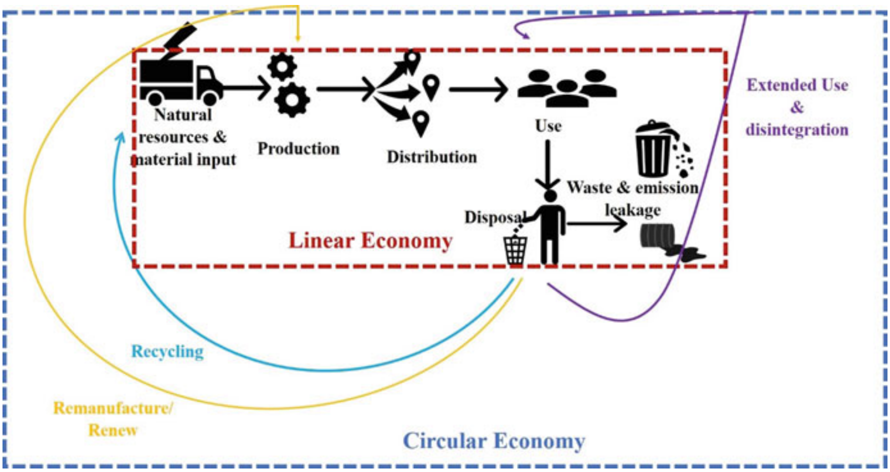

Fig. 3.1 Linear v/s Circular economy

3.3 Circular Economy in the Agricultural Sector

In order to meet the demand for food in 2050, studies show that agricultural production around the world needs to rise by 70% (Aznar-Sanchez et al. 2020). In a typical business scenario, there are two ways to reach this goal: either by expanding the amount of land used for agriculture, which in 2017 accounted for about 37% of the total available surface (FAOSTAT 2020), or by increasing production in the areas that are already being farmed, which could increase the amount of land used for agriculture by up to 38% while increasing global water consumption by 53% (Alexander et al. 2015). Therefore, such rising agricultural demand has imposed a disequilibrium between production and environmental preservation, concomitant with a significant obstacle to the sustainable long-term management of natural resources (Rufi-Salis et al. 2020; Vanhamäki et al. 2020). For these reasons, the concept of the "circular economy" has emerged as a viable option for maximizing economic output while simultaneously minimizing the detrimental effects of agricultural activities on the environment (Stegmann et al. 2020).

Resource efficiency is the core axis of decision-making and economic practices, as stated by Canales et al. (2019), in order to guarantee higher added value and keep resources inside the production system for as long as possible. To maximize productivity in circular agriculture models, it is important to optimize procedures so that resources are used as efficiently as possible and no unnecessary by-products are created (Sherwood 2020).

Sustainability is a key concept when addressing the adoption of a circular economy in agriculture. Since the circular economy strives to promote sustainable development by fostering economic and social prosperity and environmental protection through the prevention of pollution (Burgo-Bencomo et al. 2019), instead of being a subsidized industry, circular agriculture should become a cornerstone of the economy to ensure its long-term viability (Bos and Broeze 2020). Additionally, it must guarantee the sustainability of biodiversity and production efficiency in its agroecosystems over time, thereby ensuring environmentally sustainable practices (Jun and Xiang 2011), and generally contribute to social sustainability (Burgo Bencomo et al. 2019) by ensuring food security, alleviating poverty, and strengthening living conditions and public health. Last but not least, it is commonly acknowledged that circular agriculture requires regenerative practices, which are considered strategies that preserve and improve ecological services (Morseletto 2020). As circular production models are established in agroecosystems, agriculture must advance to include regenerative technologies that seal nutrient loops, reduce leakage, and enhance each loop's durability in terms of its value (Morseletto 2020).

However, adopting circular models in agriculture necessitates a paradigm shift in the production and use of agricultural goods. Value chains must be reorganized to improve local product marketing and create business models that allow materials to cascade until they are assimilated into the ecosystem, preventing the loss of priceless nutrients. Consumers must adopt a more environmentally conscious mindset and support the growth of this type of business model through their purchase decisions (Velasco-Munoz et al. 2021).

3.4 How Circular Economy Supports Sustainable Development

Since the circular economy and sustainable development are related ideas, circular economy might be used as a useful instrument to support sustainable development (Corona et al. 2019; Millar et al. 2019; Skvarciany et al. 2021). The circular economy's guiding principles have numerous advantages for the environment and society, including limits on energy use, waste production, and resource use, and they directly support the possibility of sustainable growth (Fellner et al. 2017; Gregson et al. 2015). As a result, the circular economy might be a powerful tool for resource conservation and reducing needless environmental exploitation. The following are some instances of how the circular economy can help advance sustainable development.

3.4.1 Cradle-to-Cradle

In 2001, Michael Braungart and William McDonough developed a new method based on the concept of eco-effectiveness in manufacturing in which everything is intended for reuse (Braungart and McDonough 2001). All products should be easily disassembled into their component parts for reuse in the creation of new items. The primary objective is to manufacture components that can be retrieved and reused. They were attempting to reduce waste to zero.

Cradle-to-cradle design, positive lists, intelligent materials pooling, and other techniques contribute to eco-effectiveness and the development of cycle material flow metabolisms (Van Dijk et al. 2014). Eco-effective material flow systems not only enable materials to keep their position as resources but also enable a continuous accumulation of knowledge that serves as the foundation for real upcycling by creating a coherent network of information flows among participants in the material flow chain (Berndtsson 2015). This ongoing accumulation of knowledge is a constant source of added value for goods and services and establishes a positive link between environmentally friendly industrial systems and long-term economic development. Beyond achieving zero emissions, the goal is to use resources in a way that preserves or boosts their value and production over time. Coherent biological and technical metabolisms ensure the availability of raw materials for industrial processes. Industry performs material recycling as part of its technical metabolism, which results in more jobs and economic activity (Braungart et al. 2007). Ecological processes inside the biological metabolism recycle materials, which leads to the renewal and replenishment of natural systems. The favorable association between biological metabolism and natural system health is the cornerstone for a constructive recoupling of the interaction between ecology and economy.

3.4.2 Performance Economy

In 1981, Stehle and Rede-Mulvey proposed that closed loops favor the reuse, repair, and remanufacture of goods over the manufacture of new goods and have positive effects in terms of job creation, economic competitiveness, resource savings, and preventing waste. This was part of a study that looked at the possibility of substituting manpower for energy. The circular economy strives to accomplish the following four basic goals: the extension of product life; the provision of services rather than goods; the development of a "functional service economy"; and a performance economy (Stahel 2020). This concept suggests that the circular economy needs to function within a framework in order to be efficient.

3.5 Challenges in Circular Economy

In recent years, scholars and institutions have widely investigated the concept of a "circular economy" as a possible approach to improving the sustainability of our economic system. Reuse, repair, and recycling are becoming increasingly important in a variety of industries. At the same time, businesses are becoming more interested in this new economic model (Elia et al. 2017). However, the framework for the circular economy still does not provide any precise criteria to support the selection of actions, nor does it provide any explicit guidance on how to put the concept into effect. In spite of all of these obstacles, the concepts that are implemented by the circular economy offer a great deal of potential (Bianchini et al. 2019). It enables a synthesis of environmental stewardship and commercial concerns by asserting that value creation is still possible within robust planetary constraints. Proponents of the circular economy, who drew inspiration from ecological principles, have turned the concept's many advantages into tangible market niches (Whicher et al. 2018).

As the idea still has some problems, it is important to study it from both an academic and a practical point of view (Merli et al. 2018) to understand how the ideas and principles of circular economy can be used in modern business practices. Even though the circular economy is mostly about managing waste, it is important to think about the following things when getting ready to use it:

3.5.1 Waste Treatment Infrastructure

In addition to the appropriate regulations, adequate personnel and infrastructure are very important components in order to achieve the prospects of the circular economy concept, in which the amount of money, work, and time that are required to prepare everything that is necessary are of utmost significance (Van Buren et al. 2016). For example, in the world's lands, rivers, and oceans, nearly one-third of all plastics are left behind because they are not collected by a waste management system and end up as litter (Rosenboom et al. 2022).

This challenge is especially acute in developing countries since those countries usually lack sufficient infrastructure for garbage handling (Nnorom and Osibanjo 2008). China, Indonesia, the Philippines, Thailand, and Vietnam account for more than half of all plastic litter; thus, enhancing waste management and recycling infrastructure in these nations might significantly reduce the amount of plastic that enters our protected environments.

3.5.2 Convenience-Oriented

Recent studies on the circular economy have shown that cultural hurdles, notably a lack of user or customer acceptance, are a substantial impediment to the spread of so-called "circular" business models. Johnson (2013) suggests adopting techniques like bringing linen bags to the grocery store and buying rice, beans, and other staples from bulk bins to live a waste-free life. The study concluded that there is more plastic garbage today than there was in the 1960s when it compared current plastic consumption trends with those of the time (Johnson 2013). Before people use a lot of single-use, disposable plastic products and packaging, there needs to be a change in how people live (Müller and Schonbauer 2020).

3.5.3 The Current Recycling Technology

From a recycling standpoint, closed-loop recycling is severely hindered by the complexity of the products and the variety of the waste. The majority of waste is made up of mixtures of several different materials, making it impossible to recycle them without first separating them, which is frequently not yet practicable. Additionally, a variety of contaminants may make a material more difficult to recycle, depending on the recycling technology. Since there are lengthy supply chains, accurate information is needed but is currently impossible to obtain. The phase of sorting is crucial to closing the material loop from a recycling perspective (Karell and Niinimäki 2019). According to the sorting perspective, automation is seen as a necessary future development because hand sorting is unable to do so at this time with the required efficiency and precision. The internal issues raised by the experts are related to the state of technology today. Recycling experts concur that it is too soon to provide explicit instructions to designers and sorters because chemical recycling technologies are still in their infancy (lab or pilot) (Gloeser-Chahoud et al. 2021). Only 2–3% of recycled plastics are transformed into goods with the same or comparable level of quality; the majority of recycled plastics are simply shredded and reprocessed into lower-value uses, such as polyester carpet fiber. This is mostly due to the limitations imposed on the methods by which plastics can be characterized according to their chemical composition and cleaned of additives. In order to encourage makers of consumer goods to make use of recycled plastics, we require improved recycling technology that is capable of preserving the material's quality and purity (Awasthi et al. 2022). When this technology is implemented on a broad scale, we will be able to begin reclaiming the economic worth of plastics, which will encourage the recycling and recovery of these materials.

3.5.4 The Business Frameworks

The global population is projected to surpass 9.5 billion by the year 2050, with a significant decrease in the number of people living in poverty compared to today, which means that a lot more people have an interest in purchasing a lot more goods. Developing countries like China, Brazil, and India are the main concern here. This is a huge step forward for human development, but it poses a serious risk to the health of our planet unless the companies that manufacture and trade goods can completely reform the way they conduct business. Companies should consider recovery and recycling when designing new products. For example, if manufacturers of lithium-ion batteries for smart phones developed their goods with identical chemical compositions, it would make it possible for more recycling since recyclers would be able to standardize their procedure (Mossali et al. 2020). This would enable more recycling. Instability, such as international conflict implementation, requires ensuring programs match the local context and including the political will to translate development programs into long-term, sustainable practices.

3.5.5 Energy System Transformation

There are many obstacles standing in the way of effective mitigation and sustainable development (Fatimah et al. 2020), and the first and most important is ensuring that people and policymakers learn from scientific and factual evidence and modify their perspectives and current consumption patterns accordingly (Maitre-Ekern and Dalhammar 2019).

3.6 Challenges to Implementing Circular Economy in India

India has one of the fastest-growing economies, and it is expected to become the major economy with the fastest growth rate (Sharma 2021). Coupled with rising household incomes, this strong economic growth has led to more spending by consumers, which is expected to reach USD 4 trillion by 2025. With 1.3 billion people, or 18% of the world's population, living on only 2.4% of the earth's surface, India is poised to face significant resource constraints (Chawla and Kumar 2022). India must start a model of development that is positive, includes everyone, and is environmentally sustainable (Akadiri and Adebayo 2021). There is more demand for land, soil, water, and materials mined from the earth. Between 1970 and 2010, India got about 420% more of its raw materials from the ground (Sharma 2021). India depends on the international market to get access to important resources like rare earth minerals and other things because its reserves are shrinking and it can't get them any other way (Verma et al. 2022). The key to leading this change toward building a low-carbon, resource-efficient economy is to find ways to use the circular economy. The way India's manufacturing sector has grown in the past isn't compatible with the planet's ability to provide and replenish resources (Dey et al. 2022). Also, the traditional approach to a linear economy creates a lot of waste at all stages of a product's life cycle. A circular economy based on sharing, leasing, reusing, repairing, refurbishing, and recycling can help decouple economic growth from resource use. This is done in a (almost) closed loop to keep as many resources from going to waste as possible.

There is huge potential for the circular economy in India. The estimated size of the recycled polyethylene terephthalate (PET) business in India is $400–550 million. According to the National Chemical Laboratory and PET Packaging Association for Clean Environment, India has a 90% recycling rate of PET, which is higher than Japan's (72%), Europe's (48%), and the United States' (31%) (Singh et al. 2022). PET waste in India is recycled by the organized sector (65%) and the unorganized sector (15%) and reused at home (10%). However, there are various difficulties in fully implementing circular economy in India.

A circular economy has global issues, such as uncertainty in product supply, quality, and return time. However, these issues are exacerbated in India due to the extended life and inadequate maintenance of the products. The first technical stage in a circular economy after product collection is the disassembly of used goods, which presents a significant challenge (Rejeb et al. 2022). Unfortunately, a lot of study has been done on the simplicity of assembly, and as a result, various tools and approaches for cost-effective assembly have been developed (Dey et al. 2021). The design for disassembly study has also begun, but the findings are not yet developed enough for industry use (Pervez 2022).

The circular economy faces institutional, technical, managerial, and societal challenges (Sohal et al. 2022). The role of the government or government agencies is crucial to easing the challenges. The government must prepare for infrastructure needs, build it, and, if necessary, invest in technology development. Important choices include the number and location of recycling facilities, the usage of recycled materials, etc. (Aarikka-Stenroos et al. 2021). In India, the majority of the designated or authorized waste electrical and electronic equipment (WEEE) recycling facilities are inoperable. However, the unorganized sector recycles a significant volume of WEEE (Jeyaraj 2021). With the right technology, the idea of urban manufacturing should be investigated. The lack of legislation, proper enforcement of legislation, and uncertain future legislation are important governmental challenges leading to a lack of top management commitment at the industry level (Bhatia and Jakhar 2021).

At the planning stage, the government should not undermine the importance of technology creation, particularly indigenous technology. Technological challenges are huge in the recycling sector if recycling is to become socially acceptable, environmentally friendly, and economically viable. The government should plan proper buyback laws that clearly mention the collection, refurbishing, remanufacturing, recycling, and disposal methods for the product. This may force businesses to partner with the government for recycling technology development. There is a scarcity of circular economy managers and advisors who can plan reverse logistics or integrated logistics activities. Even developed countries like Germany are facing a human resource crunch in this sector (Manniche et al. 2017). India can take the lead if there are proper technical courses in this sector. Proper courses can be designed for all three tiers of technical education. Two important social challenges are the lack of awareness and the lack of public pressure. Additionally, the public needs to be made aware of the unscientific disposal of CFLs, LEDs, WEEE, and other items as municipal waste. To avoid creating obsolete plans and wasting public money, government authorities should be well aware of the latest technologies and possibilities for recycling hazardous items.

To develop and implement circular economies for various sectors, the government should bring together various stakeholders, including non-profits, social scientists, and technology professionals. The benefits of a "circular economy" must be considered in terms of both environmental and social as well as economic benefits.

3.7 Limitations of Circular Economy

The circular economy is a synthesis of scientific and semi-scientific concepts (Korhonen et al. 2018). Circularity has over 300 definitions; therefore, it means various things to different individuals (Kirchherr et al. 2017). Policymakers, enterprises, business consultants, business groups, and business foundations have developed and used the theory and its implementations (Korhonen et al. 2018). Circular economics research communities differ greatly (Korhonen et al. 2018). The circular economy is fragmented conceptually (Blomsma and Brennan 2017) and lacks paradigmatic strength (Inigo and Blok 2019). The circular economy is a new way of manufacturing and using things in industry (Korhonen et al. 2018).

It's a multiplicity (Corvellec et al. 2020), an umbrella notion that excites people since it can address many problems. When put into practice, individuals have doubts about what it implies (Blomsma and Brennan 2017). Circular economy has many connotations, which may be why it's popular (Velis 2018), but it's hard to explain.

"Circular economy" ignores many facts. It ignores the thermodynamic concept that one cannot create or destroy matter; consumed resources must end up in the environmental system; they can only be converted and dissipated (Giampietro and Funtowicz 2020). A future without waste, closed material loops, and infinite recycling is impossible. Material characteristics and manufacturing and reprocessing processes limit material loop closure (Velis and Vrancken 2015). Dissipation, pollution, and material wear limit the circular economy (Parrique et al. 2019). The circular economy doesn't fully address waste's complexity (Mavropoulos and Nilsen 2020) and underestimates the difficulties of connecting waste streams to production and substituting secondary goods for primary goods (Zink and Geyer 2017). Waste as a resource may increase demand rather than reduce waste volumes (Greer et al. 2021). A true circular economy approach should take massive stocks and secondary materials into account (Mavropoulos and Nilsen 2020).

Supporters of the circular economy and circular business models have been found to have a simplified view of consumption as buying and recycling (Casson and Welch 2021), of citizens as consumers, and of consumers as users (Hobson 2020). This means that citizens are expected to accept or reject practices that designers, engineers, economists, and policymakers have made for them (Hobson 2016). Circular strategies also don't take into account the large amounts of used materials and objects that are stored in homes, businesses, and infrastructures (Fellner et al. 2017). The circular economy is a way of doing business and doing research that focuses on flows instead of stocks. And yet, the potential rebound effect, also called Jevon's paradox, is an unsolved problem for the circular economy. This is because efficiency improvements at the level of individual products are offset by a rise in consumption and use of materials (Schroder et al. 2019). Eventually, these effects could be especially noticeable in developing economies (Zink and Geyer 2017). Also, the way goods move around may keep hazardous substances in the economy that should be phased out, which would increase the spread of dangerous elements (Johansson et al. 2020).

Circular economic techniques have been used without explicit system constraints (Inigo and Blok 2019). Its technocentric view bridges a gap between a comprehensive approach and end-of-pipe strategies that focus on growth and competitiveness rather than social and environmental concerns (Friant et al. 2021). Policy instruments are offered to get things moving, not to stop the linear economy. In the waste industry, implementation attempts adopt a top-down approach that favors a single, centralized waste treatment technology, ignores how hard it is to anticipate the future, and makes it difficult to adapt. Unknown system boundaries, the unpredictability of the waste industry, and imprecise governance make it impossible to evaluate, appraise, and enhance economic circularity (Schroder et al. 2019). This increases the possibility of less-than-ideal practices (Webster 2013) and makes it difficult to determine what type of circular future is being built (Volker et al. 2020).

A linear business model is validated when a certain number of products or services are sold; a circular model is validated when recirculated products are sold (Linder and Williander 2017). Technical barriers include insufficient technology or a lack of technical support and training; economic barriers include high initial costs or uncertain returns and profits; institutional and regulatory barriers include a deficient legal system or an inadequate institutional framework; and social and cultural barriers include consumer rigidity. Companies lack the skills needed to adapt innovative business models for the circular economy (Pieroni et al. 2021), so the concept is rarely implemented (Khan et al. 2021).

The circular economy promises "green growth" and the decoupling of economic and environmental growth. Building circular material flows is considered by some as a way to decouple but not as an objective in itself (Blum et al. 2020). Circular economy and sustainability are often confused, despite the latter's comprehensive nature. The dubious conceptual link between the two conceptions has yet to be adequately described (Millar et al. 2019).

There is a clear need for conceptual coherence about definitions, plans, implementations, and modes of evaluation before the circular economy can become mainstream and move beyond the realm of sustainability and circular economy professionals. This is because, in the absence of coherence, the expansion of new knowledge could be obstructed by deadlocked debates or collapse entirely (Kirchherr et al. 2017).

3.8 Recent Initiatives in Circular Economy

In a large country like India, 1.2 billion people live in urban areas. Together, they make about 62 million metric tons of municipal solid waste (MSW) every year. By 2030, this amount should reach 165 million metric tons per year (Cheela et al. 2021). Because of this, the already huge amount of greenhouse gas (GHG) emissions from municipal solid waste (MSW) is expected to double by 2030, adding up to 41 million metric tons of CO_2 emissions (Sharma and Sinha 2023). The NAMA (Nationally Appropriate Mitigation Actions) Support Project (NSP), "India—Waste Solutions for a Circular Economy," has the goal of achieving a low-carbon transformation of the Indian waste sector. This will be accomplished by increasing and de-risking investments as well as strengthening the regulatory framework. This will ensure uptake of the Reduce, Reuse, and Recycle concept as well as leverage the strengths of the informal recycling sector. In addition, the NAMA Support Project (NSP) makes it easier to carry out extended producer responsibility (EPR) by providing channels that promote the coordinated engagement of a variety of stakeholders (Khatri-Chhetri et al. 2021). The project is expected to result in direct GHG emission reductions of more than one million metric tons during project execution and approximately seven million metric tons cumulatively 10 years after project completion.

AAKAR Innovations is the sole manufacturer of entirely compostable and biodegradable sanitary napkins. Access to sanitary napkins is crucial for the social inclusion of women, and the biodegradable design eliminates the enormous environmental impact of commercial plastic pads. They are also attempting to increase awareness about Menstrual Health Management (MHM) and intend to educate communities about the significance of feminine hygiene. Women are also empowered during the manufacturing process, which takes place in villages across India and Sub-Saharan Africa (Zhongming et al. 2021).

PlastiCircle, which is funded by the European Union's Horizon 2020 research and innovation program, is introducing advanced techniques for garbage collection, transportation, sorting, and recycling with the goal of converting plastic packaging waste into valuable products (Roche Cerasi et al. 2021). They are developing smart containers to boost the collection rate of plastic rubbish, cost-effective waste transport systems linked to IoT cloud platforms, breakthrough optical sorting technologies to improve sorting, and innovative recycled plastic commodities with added value. They are also attempting to redefine business ideas and promote replication of recommended solutions through training and awareness-raising actions for individuals, institutions, and private businesses. They are doing so throughout Europe, most notably in their three pilot cities: Alba Iulia, Romania; Valencia, Spain; and Utrecht, the Netherlands (Habek and Villahoz 2018).

The German government has set a target of 15 million electric vehicles on the road by 2030 in order to meet its climate goals (Sun et al. 2020). Consequently, the growth of electromobility will continue to accelerate over the next few years. The demand for lithium-ion batteries for the vehicle's drive system (traction batteries) is increasing as the number of electric vehicles increases. Since lithium-ion batteries are a crucial component of electric vehicles, it is becoming increasingly important that these batteries are produced, utilized, and recycled in an environmentally responsible manner. The primary objective of the Battery Pass project is to contribute to an internationally accepted battery passport by the end of 2024 (Zhao et al. 2021). The project encompasses content-related and technological standards, cooperation with stakeholders, demonstration, and analytic benefit evaluation. The creation of scientifically sound material, co-created by industrial partners and approved by actors in civil society, will maximize acceptability and benefit. The Battery Passport promotes the circular and sustainable management of vehicle traction batteries by providing a digital infrastructure for the documentation and exchange of fundamental information and up-to-date technical data (Schaarschmidt et al. 2022). In particular, statistics that exhaustively characterize the sustainability and accountability of the supply chain are documented, including the GHG footprint, working conditions in raw material extraction, and battery condition determination.

3.9 Conclusions

By 2050, the annual amount of waste produced globally is projected to increase dramatically, from 2.01 billion metric tons per year to 3.4 billion metric tons per year. Loss of biodiversity, air, soil, and water pollution, resource depletion, and unsustainable land use are all increasing threats to Earth's ability to sustain life. The concept of a "circular economy" may prove to be an efficient method of waste disposal. The minimization of waste and the maximization of resource utilization are essential tenets of this system. It explains how we can protect our natural resources by implementing a set of social and economic policies in tandem with advances in science and technology. Principles of the circular economy include reducing resource use, waste production, and energy needs, all of which have positive effects on the environment and society. The agricultural industries' adoption of the circular economy appeared to be a promising one to seal nutrient loops, prevent leakage, and raise the value of each loop. Circular systems, such as cradle-to-grave and performance economies, have a lot to offer the cause of sustainable development, and this is brought to light by the connection between the circular economy and sustainable development. Waste treatment facilities, recycling technology difficulties, a profit-driven corporate model, and other obstacles all stand in the way of a more circular system. There are still problems with the circular system paradigm. It's impossible to conceive of a world without garbage, closed material loops, and endless recycling. Considering the intricacy of waste, the circular economy falls short. However, with the goal of creating a more sustainable and environmentally friendly society, many new circular system-based projects have been launched, including the NAMA Support Project (NSP), AAKAR, and PlastiCircle. Furthermore, the government should work with non-profit organizations, social scientists, and technology experts to expand opportunities for the implementation of the circular economy concept in various commercial and domestic sectors, taking into account the environmental, social, and economic benefits of such a paradigm.

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