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Circular Economy can Provide a Sustainable Global Society

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Abstract

Since start of the Industrial Revolution about 260 years ago, the negative effects from the traditional linear economy (LE) become threat to the stability of the economies and natural ecosystems. Strength of climate change, reduction of environment pollution and integrity of ecosystems are essential issues for survival of the global humanity. According to LE resources for production are easily available and unlimited, and after use wastes are disposable. The circular economy (CE) is an alternative to the LE where the resources may be used for as long as possible. It tries to capture the value of existing products and materials, and decreases the use of primary materials in industries. The CE is a part of environmental economics and beneficial to the society. It keeps products, components, and materials at their highest utility and maximum value at all times. At present CE is one of the most focused terms among environmental economic scientists. The aim of this study is the implementation of the sustainable development strategies and the transition from LE towards CE.

Keywords: Circular economy, Economic growth, Recycling, Reuse, Reduction, Sustainable development, SWOT analysis.

JEL Codes: A1, O1, P2

1. Introduction

Recently global production and consumption of various commodities have increased due to the rising of global population and economic development. As a result environment pollution increases alarmingly. The circular economy (CE) substantially can reduce the environmental pollution. It is an economic system that rethinks to use raw materials and resources for the creation of a sustainable economy; free of waste and emissions. It converts the waste into valuable resources in the economy. The CE mainly emerges from 3R's principles: Reduction, Reuse and Recycle (Preston, 2012). It means shifting from the traditional unsustainable linear economy (LE) (Figure 1) of “*take, make, waste*” (i.e., goods are manufactured from raw materials, sold, used and then incinerated or discarded as waste) to a sustainable economy (Figure 2) of “*reduce, reuse, recycle*”. It is an industrial system that restores renewable energy and eliminates toxic chemicals and wastes from the environment. Recently CE attracted increased attention to the major global companies, policymakers and environment economic scientists (Ellen MacArthur Foundation, EMF, 2013). According to CE “*Nothing is lost, everything is transformed*” (Alexandru & Taşnadi, 2014).



Figure 1: Linear economy. Source: (EMF, 2016).

Actually CE cannot ensure 100% implementation of 3R's principles in the society (Andersen, 2007). Everything as much as possible is reused, remanufactured, and recycled back into a raw material and used as a source of energy. The negative effects of waste are threatening to economies and ecosystems (Park & Chertow, 2014). The CE also requires water and energy to come from renewable resources and that biological materials, such as food wastes, are returned to the soil (Natural Scotland, 2013).

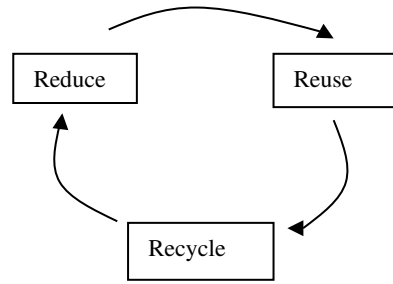


Figure 2: Circular economy. Source: (EMF, 2016).

The CE can be classified into upcycling and downcycling (Cullen, 2017). Upcycling (creative reuse) refers to converting a waste material into something of better quality or better environmental value (Sung et al., 2014; Braungart et al., 2014). For example, conversion of waste plastics into carbon nanotubes, such as graphene indicates upcycling (Zhuo & Levendis, 2013). On the other hand, downcycling indicates that materials are recovered and converted into materials of lesser quality. For example, i) a plastic computer case conversion into a plastic cup, which then becomes a park bench, and ii) steel scrap from end-of-life vehicles is often contaminated with copper from wires and tin from coating becomes lower quality steel and mostly applied in the construction sector indicate downcycling (Cullen et al., 2012). The terms *upcycling* and *downcycling* were first used by Reiner Pilz in an interview by Thornton Kay in SalvoNEWS in 1994 (Kay, 1994). Downcycling can help to keep materials in use, reduce consumption of raw materials, and avoid the energy usage, greenhouse gas (GHG) emissions, air pollution, and water pollution of primary production and resource extraction (Pires et al., 2019).

The transition to CE does not only amount to adjustments aimed at reducing the negative impacts of the LE, but also reflects a systemic shift that builds long-term resilience, generates business and economic opportunities, and provides environmental and societal benefits (EMF, 2013). Recently urbanization, industrialization, and globalization have increased globally. More than two-thirds of the world's energy is consumed in cities. Various activities of cities emit of more than 70% of global CO₂. Between 1900 and 2015, the urbanized population increased from 14% to 54%. Natural extraction of resources has increased 12-fold between 1900 and 2015. The global materials use has increased from 26.7 billion tons in 1970 to 84.4 billion tons in 2015, and it is expected that the use will be about 184 billion tons by 2050 (Circle Economy, 2019).

During the last five decades, global population, food production, and energy consumption have increased approximately 2.5-fold, 3-fold and 5-fold, respectively. Global material extraction became more than doubled from 36 billion tones in 1980 to 85 billion tones in 2013. Human activities are already affecting climate change, biodiversity, biogeochemical flows and land system (Mohajan, 2015; Steffen et al., 2015). The CE ensures renewable, reusable, and non-toxic resources to utilize materials and energy in an efficient way which provides economic, environmental, and societal benefits. It causes gradually decoupling economic activity from the consumption of finite resources, and designing waste out of the system (Geissdoerfer et al., 2017). It aims to keep products, components, and materials at their highest utility and value at all times to keep resources in use for as long as possible, extracting the maximum value from them whilst in use, and recovering and regenerating products and materials at the end of their service life (Benton & Hazell, 2013).

Since the Industrial Revolution humankind has been using raw materials for the production and consumption of goods and wastes are unconsciously discarded (Mohajan, 2019b, 2020). The CE is an industrial model that is regenerative by intention and design, and aims to improve performance of resources. It offers a new chance of innovation and integration between natural ecosystems, businesses, our daily lives, and waste management (EMF, 2014). The world population and middle classes in every nation are increasing very rapidly, the total demand for materials are increasing in parallel. To feed the global population, about 60-70% more food will be needed by 2050, redesigning our economy and protecting and regenerating biological systems can meet these challenges that are provided by CE. So CE is necessary, as it leads to lower material needs (EMF, 2012).

To achieve CE, recycling, efficient use of resources, refurbishment and reuse of products and components, utilization of renewable energy sources, remanufacturing, product life extension, product sharing, and waste prevention are needed (Rizos et al., 2017).

2. Literature Review

Kenneth E. Boulding claimed that circular systems within the global economy are unavoidable in order to guarantee human life on the earth in the long run (Boulding, 1966). David W. Pearce and R. Kerry Turner agreed that the traditional LE without recycling elements cannot be sustainable and consequently must be replaced by a circular system (Pearce & Turner, 1989). According to Robert Meril,

Michele Preziosi, and Alessia Acampora CE is a concept that shares many common principles of recycling with others which are beneficial to the society (Merli et al., 2017). Walter R. Stahel and Genevieve Reday conceptualized a loop economy to describe industrial strategies for waste prevention, regional job creation, resource efficiency, and dematerialization of the industrial economy (Stahel & Reday, 1976).

Sylvie Geisendorf and Felicitas Pietrulla propose a revised definition of the CE after having analyzed and compared the most prominent related concepts (Geisendorf, & Pietrulla, 2018). The Ellen MacArthur Foundation, a nonprofit organization, developed the refinement and development of the concept of CE as regenerative design, performance economy, cradle to cradle, biomimicry and blue economy. According to it, CE is the transformation and use of the natural resources in such a manner as to maintain and preserve the ecologic equilibrium and the economic growth (EMF, 2013). In a review paper Patrizia Ghisellini, Catia Cialani, and Sergio Ulgiati have discussed the origins, basic principles, advantages and disadvantages, modeling and implementation of CE globally (Ghisellini et al., 2016).

Mikael Skou Andersen realizes that CE provides a beneficial and inclusive economy by focusing on minimizing resource consumption and waste disposal (Andersen, 2007). Shan Zhong and Joshua Pearce stress on enhancing the CE in plastic recycling. According to them plastic waste is upcycled into 3-D printing filament with a recyclebot, which is an open source waste plastic extruder. This process benefits the environment and sustainability as well as the economic stability of consumers (Zhong & Pearce, 2018). William McDonough and Michael Braungart for a new way of designing our material goods and for going beyond the concept of eco-efficiency which only focuses on reducing the negative impacts of human activity on the environment (McDonough & Braungart, 2002). Felix Preston suggested that industrialized nations and companies must take several practical steps, such as best practice and knowledge sharing, smart regulation, standardization, raising public awareness, and support for development of nations in pursuit of CE (Preston, 2012).

Luc Alaerts and his coauthors briefly discuss the monitoring frameworks based on macro indicators that summarize the progress at national level, and micro indicators tailored towards assessing circularity at the level of products. They have developed a conceptual approach that aims to bridge the gap between the micro and macro level with meso level indicators (Alaerts et al., 2019). Marco Pesce and his coauthors have discussed SWOT analysis and implementation principles of CE

sustainability practices in companies, different industries, and territories for the development of the green energy industry in China (Pesce et al., 2020).

World Health Organization (WHO) shows that the transition to a CE provides a major opportunity to obtain substantial health benefits. It also indentified the risks of adverse and unintended health effects in processes involving hazardous materials during the implementation of CE (WHO, 2018). Vasileios Rizos, Katja Tuokko, and Arno Behrens developed a framework consists of eight main processes of the CE: i) recycling, ii) efficient use of resources, iii) utilization of renewable energy sources, iv) remanufacturing, refurbishment and reuse of products and components, v) product life extension, vi) product as a service, vii) sharing models, and viii) a shift in consumption patterns (Rizos et al., 2017).

3. Methodology of the Study

Research methodology indicates the logic of development of the process used to generate theory that is procedural framework within which the research is conducted (Remenyi et al., 1998). It provides us the principles for organizing, planning, designing and conducting a good research. Hence, it is the science and philosophy behind all researches (Legesse, 2014). The methodology of this article is to discuss CE in some details. Linear economy is one directional economy where produced materials become wastes after consumption which is sometimes called “cradle to grave” economy. On the other hand, circular economy is sometimes called “cradle to cradle” economy. Source of CE are from 3R’s principles: Reduction, Reuse and Recycle (Preston, 2012).

The CE becomes essential for the sustainable economic development and for the welfare of the global humanity. In this study secondary data are used to develop this article. For the collection of secondary data we have used both published and unpublished data sources. The published data are collected from: i) national and international journals, ii) various publications of foreign governments or of international bodies and their subsidiary organizations, iii) various research reports of research scholars, iv) books of famous authors, research note books, hand books, theses, magazines, and newspapers, v) websites, and vi) public records and statistics, historical documents, and other sources of published information. The unpublished data are collected from diaries, letters, unpublished biographies and autobiographies, and also from scholars and research workers, trade associations, and other public/private individuals and organizations.

4. Objective of the Study

Main objective of this study is to represent the aspects of CE against the traditional LE. It also will be carried out under the following specific objectives:

- To provide a basic understanding of CE.
- To show the procedure of CE among different nations.
- To highlight different levels of CE.
- To describe in brief benefits, importance and barriers of CE, and its SWOT analysis.

5. Concepts of CE

The CE in area development is still in its infancy. It is considered a possible solution to mitigate problems, such as the increasing global demand for resources, climate change and worldwide pollution. The CE has links to many of the 17 Sustainable Development Goals (SDGs), such as no poverty, responsible consumption and production, sustainable cities and communities, and the promotion of inclusive and sustainable industrialization and innovation, approved by the UN in 2015 (Berg et al., 2018). The CE is a model of production and consumption, which involves sharing, renewing, leasing, reusing, repairing, dematerializing, upgrading, refurbishing and recycling existing materials and products as long as possible. Recently CE became popular worldwide for the sustainable economic development and to make a harmonious society (Naustdalslid, 2014).

There is no unequivocal definition of CE. There is a close link between the concepts of the CE and sustainability (Whalen et al., 2018). Julian Kirchherr, Denise Reike, and Marko Hekkert defined CE as, “*The circular economy is an economic system based on business models that replace the concept of end-of-life with reducing, reusing and recovering raw materials in production, distribution and consumption processes, by operating at different levels of scale and with the aim of achieving sustainable development for present and future generations*” (Kirchherr et al., 2017). The Ellen MacArthur Foundation defined the CE as, “*A circular economy is one that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles*” (EMF, 2016).

The Chinese CE promotion laws define CE as, “A generic term for the reducing, reusing and recycling activities conducted in the process of production, circulation and consumption” (China Council for International Cooperation on Environment and Development, CCICED, 2008). The World Economic Forum defined CE as, “A circular economy is an industrial system that is restorative or regenerative by intention and design. It replaces the end-of-life concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse and return to the biosphere, and aims for the elimination of waste through the superior design of materials, products, systems and business models” (Schwab, 2019). The EU Action Plan defined the CE as, “In a circular economy the value of products and materials is maintained for as long as possible; waste and resource use are minimized, and resources are kept within the economy when a product has reached the end of its life, to be used again and again to create further value” (European Commission, EC, 2015).

In a CE, economic activity builds and rebuilds overall system of sustainable economy. The CE indicates the importance of the economy to work effectively in large and small businesses, organizations and individuals locally and globally. The aim of CE is to less use of natural resources, reduction of pollution, tackle the climate change, enhance consumer satisfaction, and improve the bottom line. It aims to design out waste. The products are designed and optimized for a cycle of disassembly and reuse. Biological ingredients be at least non-toxic and possibly even beneficial, and safely be returned to the biosphere. The energy required to fuel should be renewable by nature to decrease resource dependence and increase systems resilience (McDonough & Braungart, 2002).

Other related approaches of CE are; cradle-to-cradle (McDonough & Braungart, 2002; Bjorn & Strandesen, 2011), symbiosis (Lombardi & Laybourn, 2012), laws of ecology (Commoner, 1971), looped and performance economy (Stahel, 2010), blue economy (Pauli, 2010), closed-loop supply chains (Bhattacharjee & Cruz, 2015), regenerative design (Lyle, 1994), natural capitalism (Hawken et al., 2000), industrial ecology, reverse logistics (Agrawal et al., 2015), resource efficiency (Birat, 2015), low waste production, biomimicry (Benyus, 1997), and sustainability (Charonis, 2012).

6. Origin of CE

The discourse on the CE originated in the early 1970s. Ecological economist Kenneth E. Boulding considered the economy as a closed and circular system with

limited assimilative capacity for the maintenance of the sustainability of human life on the earth in the long run but he did not use the phrase ‘circular economy’. He called the LE as “cowboy economy” and proposed the “spaceman economy” for CE (Boulding, 1966). In 1989, British environmental economists David W. Pearce and R. Kerry Turner primarily introduced the concept of circular economic system depending on the studies of K. E. Boulding. According to them the traditional LE without recycling elements cannot be sustainable. They identified four economic functions of the environment as; i) provision of resources, ii) amenity values (e.g., the beauty of landscapes) iii) life support system, and iv) sink for waste and emissions (Pearce & Turner, 1989).

Origins of CE are mainly rooted in ecological and environmental economics and in industrial ecology. Essence of CE is found in General Systems Theory and Industrial Ecology (IE) (Preston, 2012; Ghisellini et al., 2016). General Systems Theory supports holism, system thinking, complexity, organizational learning and human resource development which are grounds of CE (Senge et al., 2010). The elements of IE are the biological analogy, system perspectives, technological modifications, cooperation, dematerialization, eco-efficiency, and research and development (White, 1994). The IE analyzes the industrial system and its environment as a joint ecosystem characterized by flows of more material, energy and information as well as by the provision of fewer resources and services from the biosphere (Erkman, 1997; Merli et al., 2017). The CE promotes the transition from open to closed cycles of materials and energy, and leads to less wasteful industrial processes (Andersen, 2007). The CE builds concepts on IE to analyze industrial systems operation and optimization to establish a new model of economic development, production, distribution and recovery of products (Iung & Levrat, 2014). It is restorative on renewable energy to minimize, track, and eliminate the use of toxic chemicals and eradicate waste through careful design. It includes the activities of contribution to zero waste and keeping materials in use for as long as possible (EMF, 2014).

7. Principles of CE

The main principles of CE are “*reduction, reuse and recycle*”. The reduction principle tries to minimize the input of primary energy, raw materials and waste through the improvement of efficiency in production and consumption processes that reduces resource and increases economic and social wellbeing. It promotes system effectiveness by revealing and designing out negative externalities (EMF, 2012; Su et al., 2013). The reuse principle indicates to use resources again in

production for the same purpose that provides environmental benefits as it requires fewer primary resources, less energy, and less labor, compared with the manufacture of new products. It preserves and enhances natural capital by controlling finite stocks and balancing renewable resource flows (EU, 2008; Castellani et al., 2015). The recycle principle refers to reprocess waste materials into products which benefit the still usable resources and reduce the quantity of waste. It optimizes natural and manmade resources by circulating products, components, and materials (EU, 2008; Birat, 2015). Some waste materials are recyclable for a limited times and some for unlimited times. For example, cellulose fibers may be recycled 4-6 times, but metals are recyclable unlimitedly (Reh, 2013).

The CE is based on following three principles (EMF, 2012):

i) Waste and pollutions are designed out. These indicate that the products of today can become the resources of tomorrow and the negative impacts of economic activity that cause damage to human health and natural systems must be eliminated. For example, the release of GHGs, the use of toxic and hazardous substances, the pollution of air, water, and land, incineration of waste, etc. are harmful for environment. Hence waste and pollutions must be redesigned (EMF, 2013).

ii) Products and materials are kept in use. This includes favoring activities that increase product utilization, and reuse to preserve the embedded energy, labor, and materials. For example, designing for durability, repair, reuse, remanufacturing, and ultimately recycling of products and materials are necessary (EMF, 2014).

iii) Natural systems are regenerated. It involves, for example, deploying agricultural practices that not only avoid degrading soil, but actually rebuild soil health over time (EMF, 2012).

The CE is founded in several principles as follows (EMF, 2012, 2013):

Eco-design: It tries to reduce the environmental impacts throughout the life cycle of a product. It circulates products, components, and materials at their highest utility at all times, in both technical and biological cycles (Erkman, 2001).

Energy from renewable sources: It eliminates fossil fuels to produce the product, reuse and recycle. It favors technologies and processes that use renewable or better performing resources (Geng et al., 2014).

Industrial and territorial ecology: It establishes an industrial organizational method in a territory characterized by an optimized management of finite stocks and balancing renewable flows of materials, energy and services. The CE enhances natural capital by encouraging flows of nutrients within the system and creates the conditions for regeneration of soil and other living systems (Erkman, 1997; Preston, 2012).

Functionality economy: It aims to eliminate the sale of products in many cases to establish a system of rental property (EMF, 2013).

Waste becomes a resource: All the biodegradable material returns to the nature and the not biodegradable is reused. Resources, wastes and byproducts of one company can become the inputs of another industrial process which reduces the use of raw materials, waste and environment pollution (Frosch & Gallopoulos, 1989).

Second use: It reintroduces in the economic circuit those products that no longer correspond to the initial consumers needs (EMF, 2012).

Reuse: It reuses certain products or parts of those products that still work to elaborate new artifacts (Geng et al., 2014).

Reparation: It finds damage products a second life. It reveals and design out negative externalities, such as land degradation, air, water, and noise pollution, release of toxic substances, and GHG emissions (Steffen et al., 2015).

Recycle: It makes use of materials founded in waste (Preston, 2012).

Valorization: It harnesses energy from waste that cannot be recycled (Mirabella et al., 2014).

8. The CE Model

The CE predicts an economy that has no net effect on the environment, restoring any damage in resource acquisition and minimizing waste generation in manufacturing and the product life cycle (Murray et al., 2015). The aim of CE is not proposing an absolute decrease in the levels of material use or a reduction in

personal consumption levels, but continuing economic growth by utilizing resources more efficiently (Llanwarne, 2016).

The CE enables to create a circular supply chain in which residual outputs from one process feed into another process, to recover the resource value of materials in a manner that creates new value from these same materials, to extend the work life of a product, and improve the usage rates of products through shared use (World Economic Forum, 2018).

The following models of CE are necessary to make the world sustainable for the future generation (Accenture, 2015):

Resource Recovery: This model enables a company to eliminate material leakage and maximize economic value of product return flows. Recovery of useful resources/energy out of disposed products (Accenture, 2015). For example, waste management company of Singapore, Tes-Amm connects seamlessly with its clients' manufacturing processes to help dispose electronics scrap.

Circular Supplies: This model is based on supplying fully renewable, recyclable, or biodegradable resource inputs that strengthen circular production and consumption systems (Accenture, 2015). For example, tyre manufacturer Omni United in Singapore has tied up with US footwear company Timberland to make a special line of tyres that can be easily recycled at the end of life into crumb rubber. The rubber is then used by Timberland for making shoe outsoles.

Product as a Service: This model offers an alternative to the traditional model of buy and own. Products are used by many customers through a lease or pay-for-use arrangement (Accenture, 2015). For example, Sunlabob, a solar enterprise based out of Lao People's Democratic Republic (Lao PDR), has created a service-based approach to sustainable lighting in rural areas.

Product Life Extension: This model indicates to extend the working life cycle of products and components by repairing, upgrading, and reselling (Accenture, 2015). For example, in Singapore, the Sustainable Manufacturing Centre and the Advanced Remanufacturing and Technology Centre have been working with companies to improve the longevity of products through topics, such as green manufacturing, remanufacturing, repair and restoration, and product verification.

Sharing Platforms: This model promotes a platform for collaboration amongst product users, either individuals or organizations. It facilitates to increase utilization rate of products by making possible shared use (Accenture, 2015). For example, car sharing is one of the earliest sharing platform models.

9. The Nations on the CE

In the last two decades many countries of emerging economies have achieved impressive environmental improvements. But over production, consumption, and trade remain dangerously unstable globally yet (Preston, 2012).

Germany followed CE in the early 1976 with the Waste Disposal Act. It implemented CE in 1996 accompanied with an enactment of a law: “*Closed Substance Cycle and Waste Management Act*” which provided for managing waste in a closed cycle and ensuring environmentally compatible waste disposal (Su et al., 2013). In 2015, the European Commission announced a CE package that marks a milestone towards a modern conception of economic growth fit for the 21st century (The Centre for European Policy Studies, CEPS, 2018).

Japan followed CE since 1991 with the Law for Effective Utilization of Recyclables and the Japanese CE initiative (The Institution of Environmental Sciences, IES, 2015). In 2000, Japan became the second country that issued a law to promote CE nationally. The government tried its best for high production, high-consumption and high waste into a “*recycle-oriented society*”. It aimed to promote waste measures and recycle comprehensively and systematically (Zang, 2006).

Rapid economic development of China has increased wealth and has provided employment and business opportunities. The rapid economic growth pushed the country in serious natural resource depletion and environmental pollution. China is the third country engaged in serious efforts to implement CE on a large scale. China started CE in 1998 and the government of China (GoC) has accepted CE since 2002 (Yuan et al., 2006). Initially it likes to retain competitiveness and intends to initially introduce the CE framework on a smaller scale through several pilot studies so that it has a better basis for assessing its large scale and full coverage in the long run. This policy is like economic liberalization, which started with coastal free economic zones (Heshmati, 2015). In 2009, China adopted “*Circular Economy Promotion Law of the People’s Republic of China*” (Lieder & Rashid, 2016). Recently China strongly followed CE because of the huge problems on environment and human health due to its very rapid and continuous economic

development pattern. The CE is identified in China within the ecological economics framework. It introduced a new development model to help China leapfrog into a more sustainable economic structure (Su et al., 2013). The CE emphasizes the benefits of reusing and recycling residual waste materials in energy, water, different byproducts, etc. For example, Dalian city in China is an important pilot study where the CE strategy was implemented during 2006–2010 (Park et al., 2010). Concept of Chinese CE vibrates with the concept of IE which emphasizes the benefits of utilizing residual waste materials, including energy, water, different byproducts as well as information (Yuan et al., 2006).

The waste and resource sector in the UK has followed the recycling, composting, anaerobic digestion, etc. Therefore, other CE activities, such as repair, refurbishment, and remanufacture are not followed significantly (Chartered Institution of Waste Management, 2014). Recently, Europe is a pioneer when it comes to CE policy development. Many members of EU states including Finland, the Netherlands, Scotland and France have launched CE strategies and initiatives (Sitra, 2016). The USA partially adopted CE since 1980s as a solid waste management, minimum content laws, labeling laws, selective landfill bans on specific materials, beverage containers recycling, and green labeling (He et al., 2013). Very recently Australia and New Zealand are evaluating and accelerating an action agenda for the CE (Jewell, 2015). A non-EU member state and a small economic power, Switzerland is trying to achieve CE policy in national and international levels (Alexandru & Taşnadi, 2014).

10. Levels of CE

There is a three-layer approach to implement CE in the society: i) micro level, ii) meso level, and iii) macro level. The CE can control production, consumption and waste in these three levels. Recently China, Europe, Japan, the USA, and BRICS (Brazil, Russia, India, China, and South Africa) are substantially benefited from the partial implementation of CE.

10.1. Micro Level

The micro level indicates the company or consumer level (single process). At this level a company is either required or encouraged to conduct CE auditing. Here all enterprises are divided into five categories; green, blue, yellow, red, and black, according to their environmental performance. A company follows different

strategies, such as production processes, green design, cleaner production (pollution prevention, toxic use reduction, and design for environment), etc. to improve the circularity of its production system. It also cooperates with other companies over the supply chain to achieve a more effective circular pattern. They are encouraged to design more environment friendly products and adopt cleaner technology in their manufacturing processes (Yuan et al., 2006; Wrinkler, 2011).

Green consumption is an important policy that takes more environment friendly products and services. The green consumers' responsibility is to purchase and use of food, non-food sustainable products and services (European Commission, EC, 2010; Su et al., 2013). The implementation of CE practices reverse supply chains and enables products at the end of their life cycle to reenter the supply chain as a production input through recycling, reusing or remanufacturing (Genovese et al., 2017).

10.2. Meso Level

The meso level indicates the eco-industrial parks, industrial symbiosis districts and networks (Su et al., 2013). At this level, the main objective is to develop an eco-industrial network that will benefit both regional production systems and environmental protection. It monitors frameworks that reports CE achievements in systems that fulfill needs of a society. The purpose of it is to achieve economic and environmental benefits (de Wit et al., 2018).

Industries work as separate entities and engage in complex interplays of resource exchange (material, water, energy and byproducts) is called industrial symbiosis. The industrial ecology cares at all levels of analysis (facility level, inter-firm level, regional and global level). But the industrial symbiosis refers at inter-firm level, as it involves physical exchanges among several organizations (Lowe et al., 1995; Chertow, 2000). The international experiences of industrial symbiosis can be mainly traced back to both top down (eco-industrial parks) and bottom up (industrial symbiosis districts) strategies (Cutaia & Morabito, 2012).

10.3. Macro Level

The macro level indicates regions, provinces, cities, and nations. The CE development in macro level can be formed by four systems as (Ness, 2008): i) the industrial system, ii) the infrastructure system, iii) the cultural framework, and iv)

the social system. The eco-city, eco-municipality, or eco-province is one of the most prominent environmental movements. The concept of eco-town was developed in the 1980s in the USA, and since 1997 a number of 26 eco-towns were created in Japan (van Berkel et al., 2009). About 100 of eco-cities were formed in Europe, such as in Germany, Sweden, and UK, and also in China (EU-ASIA, 2014; Marion, 2012).

Every year about 2.5 to 4 billion metric tons of wastes are collected worldwide and 1.3 billion tons of solid waste per year is generated in cities. Dangerous chemicals and metals, such as mercury, cadmium, lead, etc. are included in electrical and electronic wastes (e-wastes) and may leach into the environment and local ecosystem (Circle Economy, 2019).

10.3.1 E-Wastes

E-waste refers all electronic equipments that have been discarded without the intent of reuse (Solving the e-Waste Problem, STEP Initiative, 2014). Recently e-waste is one of the fastest growing waste flows in all nations. Production of e-waste increased from 20 million tons in 1998 to 41 million tons in 2010 globally (Kuehr, 2012). In 2016, about 45 million tons of e-wastes were produced worldwide, and only 20% of it was collected and recycled appropriately. By 2020, e-waste from old computers in South Africa and China will have jumped by 200-400% and by 500% in India from 2007 levels (EMF, 2016).

10.3.2 Plastics Waste

Used plastic is considered as one of the elements of waste. More than last 50 years plastics use has increased due to their versatility, low cost and durability. Recently plastic has improved standards of living of the people (Shen et al., 2009). Between 1964 and 2015 the production of plastics increased by more than twenty-fold. In 2015, the global plastic production was 322 million tons; roughly two-thirds of which were contributed jointly by China (23%), EU (21%), the USA (16%), and Japan (5%). The production is growing 3.86% per annum, and is expected to increase about 850 million tons per year by 2050 (Gu & Togay, 2016).

Plastic is used in many sectors, such as packaging, baggage, financial transactions (Debit/Credit cards, plastic money), food containers, stationary items, toys, shoes, storage, electrical and electronic goods, household appliances, construction,

automotive manufacture, furniture, agriculture, etc. At the beginning, it was mostly produced in Europe and the USA, but recently China became the leading producer with 28% of global production, and Japan 21% (Gopal et al., 2014).

About 4,900 million tons of the estimated 6,300 million tons totals of plastics ever produced have been discarded either in landfills or elsewhere in the environment. Plastics usually need more than 20 to 500 years to break down in landfill; incineration of plastic emits large quantities of harmful compounds and GHGs (Tansel & Yildiz, 2011).

Plastic production is highly dependent on natural gas and oil (6% of global oil). It takes about 185 liters of water to make one kg of plastic. Some plastics contain toxic chemical additives, including persistent organic pollutants (POPs), which have been linked to health issues, such as cancer, mental, reproductive, and developmental diseases. Plastic is also harmful for the environment, such as climate change, marine pollution, biodiversity, and chemical contamination (Barra & Leonard, 2018).

A new plastic recycling 3-D printing filament with a recyclebot can recycle waste plastic, and then the postconsumer plastics can be turned into useful and more valuable products. A 3-D print-based manufacture can save materials, reduce energy consumption and decrease GHG emissions (Baechler et al., 2014; Redlich & Moritz, 2016). In 2011, recycling rate were 78% in Japan, 59% in EU, 48% in China, and 8% in the USA (Zhuo & Levendis, 2013).

It is estimated that only 9% of the 6,300 tons of plastic waste generated between 1950 and 2015 was recycled. India has probably the highest plastic recycling rate with estimates ranging from 47 to 60% (Plastic Europe, 2016). Waste management policy is crucial for the CE, so that the best overall environmental outcome is obtained.

11. Business Facilities in CE

Recently global resources and the climate faced heavy pressures due to human activities and CE can help to reduce these global sustainability pressures (Intergovernmental Panel on Climate Change, IPCC, 2014; EMF, 2014). The CE activities, such as boosting recycling, save valuable materials, create new jobs, develop expertise, enhance eco-design, move towards zero-waste, reduce GHG emissions, etc. As a result global business can improve smoothly (EC, 2014). The

CE can create a new business which is expected to lead to a more sustainable development and a harmonious society (Mathews & Tan, 2011). It can create a more appropriate and environmentally sound use of resources that can develop a new business model and innovative employment opportunities by implementing greener economy (EMF, 2012). It reduces material costs and diminishes resource dependence, and saves billions of dollars (Sariatli, 2017).

12. Effects of Knowledge Sharing in CE

The CE enhances natural capital, optimizes total resources, and minimizes system risks by the efficient management of finite stocks and renewable flows (de Man & Friege, 2016). Knowledge (explicit and tacit) sharing (KS) in CE can enhance the global sustainable economic development. The CE can save massive costs of production by recycling the wastes. Social innovation associated with sharing, eco-design, reuse and recycling can create sustainable consumer behavior and improve human health, and KS can increase the CE more rapidly. Public awareness on negative effects of waste (e.g., open dumping, littering and waste segregation) can expand among mass people with the help of KS (Wysokinska, 2016; Mohajan, 2019a).

KS is essential for every company and every industry to face the global economic competition. It also can improve the principles of CE. Germany, China, Japan, BRICS, and other nations who initiated CE must share knowledge among them and with other nations to implement CE globally.

13. SWOT Analysis for CE

SWOT is acronym of strengths, weaknesses, opportunities and threats. It is a tool used by companies to understand and improve their operations. It is a scientific analysis method that combines the internal resources and external environment of a company or an organization. It helps the companies to face the current challenges efficiently and discover new technologies to develop them. To survive in a competitive market a company has to handle different internal and external strategies and SWOT analysis can help in this regard. Of the four branches of SWOT analysis; strengths and weaknesses are internal factors, and opportunities and threats are external factors (Humphrey, 2005).

There are enormous benefits or strengths and opportunities of CE but, it also has huge challenges, such as weaknesses and threats. The CE reduces wastes, recyclables resources, increases profit, creates new jobs, provides sustainable environment, etc. On the other hand, it is in quite infancy and has to pass a thorny way. Governments spend minimum amount for the implementation of CE. More campaigns, R&D, and collection of capital are needed to implement CE in the society. The SWOT analysis of CE is given as follows (Sariatli, 2017; Pesce et al., 2020):

Strengths: These are positive internal factors to the organizations, which are favorable quantities to the management and performance of a company. Strengths of CE are:

- using the R&D activities in CE a company can produce higher quality and more durable articles,
- proper guidance, principle, target and strategy can implement CE into the organizations,
- proper waste management policies can enhance the CE in all nations,
- elimination of municipal wastes CE can present cleaner environment,
- innovation can help organizations to find new opportunities by studying both internal and external factors,
- due to the closed-loop processes, price fluctuations of the materials can be stabilized,
- there are many scopes for the involvement of experts and experienced people in CE projects,
- reinforces leadership and motivates the implementation of CE,
- CE can reduce the use of raw materials and can present sustainable society, and
- it reduces the risk for an organization if it operates in a wrong way.

Weaknesses: These are negative internal factors to the organizations that work against the development of functioning management practices and performance of a company. Weaknesses of CE are:

- no precise guidelines and management system for implementation of CE are given yet,
- depends on the availability of information (e.g., sustainability-related, safety-related, CE-related, end-of-life-related information),
- there is still no internationally recognized standards institution to regulate the CE,
- lack of guided processes for improving stewardship,

- employees have limited knowledge to run the CE activities efficiently,
- there is a gap between theory and practice,
- knowledge of CE is not efficiently transformed to common people,
- lack of knowledge on how to implement transparency,
- social marketing campaigns are not sufficient to develop CE,
- lack of methods to implement systems thinking in a profitable way,
- highly dependent on top management's decision-making,
- investments and supports, such as money, human resources, training and attention from management team are not enough to implement CE in all sectors, and
- if organizations face uncertainty about their activities and decisions with wider sense, it will be difficult to implement CE.

Opportunities: These are positive external factors to the organizations, which implement the principles that can bring fortune to the company. Opportunities of CE are:

- CE can reduce the use of raw materials in industries during the production and can save costs,
- CE can strengthen relationships with stakeholders, such as public, government, and customer,
- CE can inspire organization in the search for technological innovation and implementation of new tools to enhance competitiveness,
- By the use of upcycling technologies in CE we can develop our economies and can reduce environment pollutions,
- By the development of CE we can achieve business opportunities globally,
- CE can create business opportunity for the entrepreneurs,
- it can lead the management team to support and improve management processes, and
- it can improve internal performance, such as leadership, teamwork, work efficiency, etc.

Threats: These are negative external factors to the organizations, which are harmful for the existing principles of the company that have taken into consideration. Threats of CE are:

- the projects may loss fast-changing market due to rapid competition,
- if companies control entire life cycle then prices of products will increase and CE cannot applied properly,
- innovative ideas could be easily copied by other competitors,

- financial disruptions in the CE can cause unpleasant outcomes,
- if it becomes difficult to benefit from waste management, CE processes can be abandoned,
- projects may abandon due to incapable of efficient staff turnover,
- at the beginning CE cannot bring enough economic benefit to meet the business expectations,
- if labor cost increases companies can fail,
- modernization of CE may not bring enough economic benefits, and
- it is difficult to manage the use of products at end-of-life if the customers have lack education on how to use and dispose them.

14. Benefits and Importance of CE

A CE has possible benefits in terms of competitive advantage, employment, waste reduction, and the environmental protection (Llanwarne, 2016). The CE promotes a more appropriate and environmentally sound use of resources aimed at the implementation of a greener economy, characterized by a new business model and innovative employment opportunities. The CE favors activities that preserve value in the form of energy, labor, and materials (EMF, 2012). By conserving materials of high-value products and high-quality secondary raw materials; CE would reduce demand for primary raw materials. At present the existing technology has maximum potential of CE strategy is estimated to be 10–17% (EC, 2011).

More regenerative farming practices, such as organic farming, closing nutrient loops and reducing food waste in food sector; factory-based industrial processes, smart urban planning, sharing of residential and office space, and energy-efficient buildings in construction, more sharing of cars and better integration of different transport modes in mobility can implement CE in the society (EMF and McKinsey Center for Business and Environment, 2015).

A CE reveals and designs out the negative impacts of economic activity that causes damages to human health and natural systems. It decreases the negative externalities; optimizes agricultural productivity, measures waste prevention and eco-design, and reuses of raw materials by reducing GHG emissions and hazardous substances. For example, emissions from industry in the EU would fall about 56% by 2050 if the CE is to become a reality (European Union, 2013). The European Commission estimates that different combinations of more ambitious targets for recycling of municipal and packaging waste and reducing landfill could lead to a

reduction in GHG emissions of around 424–617 million tons (48%) of CO₂ equivalent over 2015–2035 (European Environmental Agency, EEA, 2016). It is realized that if the EU manufacturing sector adopted CE business models, can save about \$630 billion per year by 2025 (EMF, 2012).

CE reduces waste, drives greater resource productivity, delivers a more competitive economy, better addresses emerging resource security/scarcity issues in the future, and helps to reduce the environmental impacts of production and consumption. It is estimated that CE for food could generate \$2.7 trillion in benefits annually for the society and the environment by averting an estimated 5 million deaths every year by 2050. The CE reduces energy intensity, material intensity, and dispersion of toxic substances; enhance the ability to recycle, increase service intensity, extend product durability, and maximize the use of renewable resources (EMF, 2013).

CE has benefits that are operational as well as strategic and brings together a huge potential for value creation in the economics, business, environment, and social spheres. The residues are seen as valuable and these are absorbed as much as possible in order to be reused in the process. Sharing, eco-design, reuse and recycling can develop sustainable consumer behavior which is benevolent for human health (EEA, 2016). The CE could provide significant cost savings for various industries. For example, food, beverages, textiles and packaging can save \$700 billion per year globally. It can create an opportunity of \$630 billion a year for only a subset of the EU manufacturing sectors and also can create about 500,000 new jobs in the UK (EMF, 2013).

A CE avoids the use of non-renewable resources and preserves or enhances renewable ones. Application of CE in agricultural system ensures that important nutrients are returned to the soil through anaerobic processes or composting that softens the exploitation of land and natural ecosystems. In this process waste is returned to the soil and the soil gets healthier and more flexible which reduce cost of fertilizer. Hence CE in farming is useful for both the soils and the economy (Ghisellini et al., 2016).

The development of CE model, together with a new regulation and organization of the labor markets, can bring greater local employment in entry-level and semi-skilled jobs. For example, in recycling and repairing practices new designers and mechanical engineers can find new jobs and new businesses employees are needed. Economies must be benefited from the CE by major net material savings, mitigation of volatility and supply risks, drivers for innovation and job creation,

regeneration and improved land productivity, and path to a strong economy (Cholifihani, 2018). It promotes virgin material minimization and adoption of cleaner technologies. For example, reuses and cycles of waste are profitable for environment (Andersen, 1999).

In brief, some benefits of CE are as follows (EMF, 2012):

- creation of new green industries and jobs,
- provision of more return and lower risk to investors,
- avoid of environmental damage caused by resource extraction,
- reduction of raw materials, reduces energy use and reduction of CO₂ emissions,
- save business, customers, and suppliers money,
- less pollution enters in the earth's life support systems,
- use of renewable energy that in the long run is less polluting than fossil fuels,
- reuse and dematerialize of fewer materials and production processes are needed to provide of good and functional products,
- energy-efficient and non-toxic materials and manufacture and recycle processes will be selected, and
- reduction in litter efficiently.

15. Barriers to Implement CE

The CE faces economic, social and environmental challenges, such as resource-related challenges for business and economies (Preston, 2012). There are many challenges in achieving high value, such as skills, training, and design implications in manufacturing (Llanwarne, 2016). The main barriers in the CE are on technological, legal, economic, and behavioral levels. Technological barriers are the processes and technologies are needed to establish closed loops and create technical and biological materials cycles. It is the need for changing and redesigning products and production systems. Legal barriers are the management of products, materials, and waste. Economic barriers are the complexities between regulations and business operations, international discrepancies, and outdated status of regulations. These are due to social and environmental externalities and are not considered in prices. Costs of raw materials are fickle and at low prices alternative, good quality secondary resources are not competitive, and the demand for circular products and alternatives is still small (Betchel et al., 2013).

Institutional barriers to CE are new business models may be challenging to implement and develop because of laws and regulations. Many companies have short-term value creation goals and appraisal systems, whereas the CE is a long-term value creation model, the GDP index does not consider social and environmental externalities (EMF, 2014).

According to a Swedish study conducted in 2017 that the main five barriers to moving towards the CE are financial, structural, operational, attitudinal and technological. Measuring of the financial benefits of CE and its profitability is a great challenge, the structural barrier is unclear within companies, the operational challenge is the difficulty of dealing and staying in control of processes within the value-chain, the attitudinal barrier is from the lack of knowledge about sustainability issues, and the technological barrier is the need for changing and redesigning products and production systems (van Ewijk, 2018).

Finally, a successful transformation to a circular model involves a new way of thinking, acting, plus communicating with others in the chain. However, an internal reluctance to move away from business as usual and to challenge current paradigms in a corporation is another risk (Rossi et al., 2016).

16. Conclusions and Recommendations

In this study we have seen that the linear economy (take-make-dispose) is not sustainable for mankind. At the life end of a product if it is used again and again then economic value is created. We have observed that CE adds value of a product as much as possible and tries to eliminate the waste. In CE waste of one process becomes the input for another process. In the study we have tried to show the implementation of CE at various levels of companies and organizations. The CE has become a high-profile issue not only in developed countries but also in developing countries. After implementation CE will be beneficial to the society and economy as a whole. The CE can be developed by strengthening waste and e-waste management policies, establishing smart cities, improving public awareness and participation in activities related to CE.

In the 21st century the world faces serious environment pollutions and global climate change due to global warming. We have to improve the 3Rs in all sectors of every nation to implement CE in the society. Europe, China, Japan, the USA and some other nations are trying to implement CE in their own societies and globally. We have tried to discuss concepts, origin, principles, and model of CE.

We further highlight business facilities and effects of knowledge sharing in CE. The study also discusses the importance and benefits, barriers, and SWOT analysis of CE.

The study will help the researchers, practitioners, environmental experts, and policymakers. From this study future researchers will find preliminary guide lines of CE. From the weak points of this study they can criticize and develop the CE in their researches.

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