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Adnan Munir Rajput[1], Omer Chughtai[2]

[1]Director, Special Investment Facilitation Council, Prime Minister's Office, Government of Pakistan

[2]Associate Professor, COMSATS University Islamabad, Wah Campus, Wah Cantt, Pakistan

Correspondence:
Adnan Munir Rajput: adnan.munir@yahoo.com

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Enhancing Industrial Competitiveness through Circular Economy Solutions in Pakistan

Adnan Munir Rajput and Omer Chughtai[*]

ABSTRACT

The circular economy (CE) is an emerging economic paradigm focused on minimising waste, maximising resource efficiency, and achieving sustainable development through closed loop systems. This paper provides a comprehensive overview of the CE concept, with a particular focus on its background, global benefits, challenges, and socioeconomic implications, particularly in the context of Pakistan. Using a qualitative research methodology that includes comparative policy analysis and expert interviews, the study examines global best practices and national CE policies in India, Vietnam, Türkiye, China, Germany, and Pakistan, identifying three globally effective CE models. It further categorises investable CE-aligned projects across Pakistan's mining, energy, agriculture, textile, and industrial sectors. The findings reveal significant opportunities for Pakistan, including the potential to generate USD 500 million in value through waste valorisation, reduce carbon emissions by 30%, and contribute an estimated 3-4% to GDP while creating green jobs. However, challenges such as regulatory gaps, insufficient infrastructure, and limited institutional capacity persist. The study highlights the interlinkages between CE and global green transitions and assesses the relevance of evolving international trade and investment regulatory frameworks and financing sources. Key policy recommendations include the development of a national CE roadmap, policy and regulatory reform, strategic infrastructure investment, targeted capacity building programmes, and active engagement with global investors and green finance platforms. These steps are essential to facilitating Pakistan's smooth and inclusive transition towards a circular and sustainable economic model.

Keywords: Circular Economy, Environment, Supply Chain, Reuse, Recycle, Digital Transformation, AI, IoT, Textile, Mining, Industry, SEZ, Green Energy, Policy, Trade, Investment.

JEL Classification Codes: E24, E61, F23, G18, G24, O13, O14, O31, O44, P28

[*]***Adnan Munir Rajput*** is Director at the Special Investment Facilitation Council, Prime Minister's Office, Government of Pakistan. ***Dr Omer Chughtai*** is Associate Professor at COMSATS University Islamabad, Wah Campus.

1. INTRODUCTION

The prevailing linear economic system, the take, make, dispose model, has been a major contributor to environmental degradation, depletion of resources and global warming. Comparatively, the circular economy (CE) suggests a regenerative model that centres on recycling, recovery, reduction, and reuse of materials to develop a closed loop system that reduces waste and maximises resources utilisation. CE frameworks are being implemented by governments and industries worldwide, whether multinational (European Union-EU), national (China), and city (New York, London, Tokyo) (Velenturf and Purnell 2021, p. 2). The interest in CE is not just theoretical. In 2013, one-third of international CEOs showed interest in CE because it addressed business interests, sustainability objectives, and corporate responsibility (Lew and Van de Perre 2024, p. 30). Economic potential is a foundation of this interest, as the global implementation of CE has the potential to generate up to USD 4.5 trillion by 2030 (Chabowski et al., 2023, p. 2). In comparison, the world economy was worth USD 80 trillion in 2017 (Semertzidis 2022, p. 1). In addition, it is projected that CE strategies will minimise greenhouse gases all over the world by up to 70 % by 2050 by engaging in low carbon and resource-efficient activities (Gielen et al., 2019, p. 4).

In Pakistan, issues of the environment like poor waste management, air and water pollution, and degradation of natural resources continue to be a problem. It produces more than 32 million tonnes of solid waste every year, and less than 10% of waste is recycled, and only 50-60% of waste is collected (Iqbal et al., 2022, p. 2). Despite the slow but steady growth of CE awareness, especially in the textile and agriculture sector, Pakistan is not doing so well in adopting it. The key barriers are a weak level of awareness among key stakeholders, waste management infrastructure shortage, and fragmentation of policies, and insufficient investment capital (Anjum et al., 2021, p. 1). Addressing these obstacles and creating a strong framework on CE governance would enable Pakistan to attain sustainable and equitable economic growth.

Other countries provide examples. The EU has already reached a 48% rate of recycling and a 5.5% decrease in municipal waste by 2010-20 (Antonopoulos et al., 2021). At the community level, such as in the case of Kamikatsu, Japan has exceeded an 80% recycling rate (Herrador 2023, p. 1). Since 2015, China, the biggest industrial polluter in the world, has already incorporated CE into more than 100 pilot cities and achieved waste reduction of more than 15% in the key industries, including cement, steel, and textile (Huang et al., 2021, p. 4). These international examples show how a specific policy, infrastructure, and investment can unleash the full potential of CE.

1.1 Definition and Principles

A CE is a system of regenerative economics that seeks to decouple economic activity with environmental degradation by moving towards a system that designs waste and pollution out of the system, keeping materials and products in use (rather than discarding them), and

regenerating natural ecosystems. Principles of core CE are:

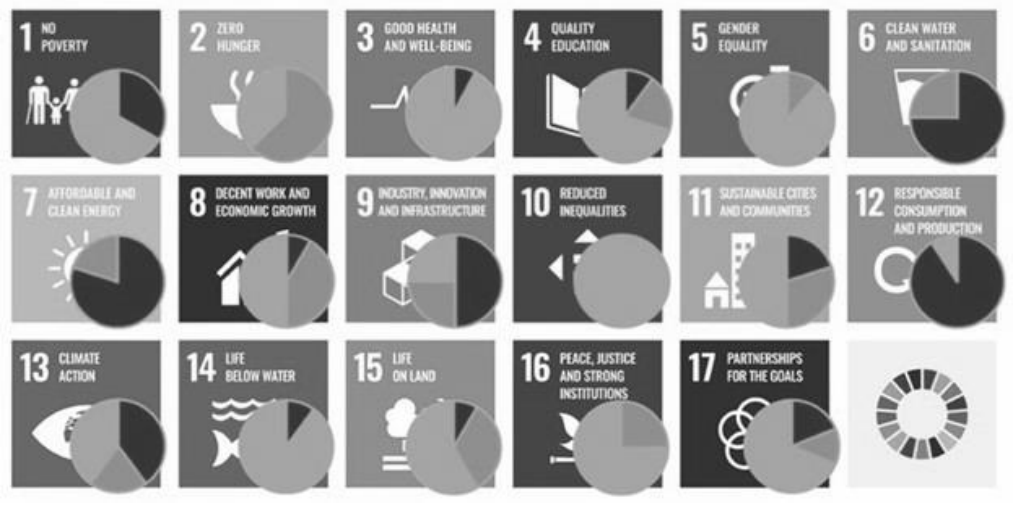
- Long-Term Design: Creating products that last, repair and recycle.
- Resource Efficiency: Maximum utilisation of resources with less input and waste reuse.
- Closed Loop Systems: Making sure that the outputs of one industrial process serve as the inputs of another.

As an example, the Kalundborg Industrial Symbiosis in Denmark is a closed loop system in which the waste heat, water and materials of one factory are used to power other industries and raise efficiency and lower environmental impact.

1.2 Evolution of Circular Economy

The history of CE can be traced to the 1970s when intellectuals such as Walter Stahel promoted a so-called closed loop economy whereby waste would be reduced, and the life of products would be maximised. The development of industrial ecology in the 1990s conceptualised production systems as networks. CE began to spread around the world in the 2000s, including the Ellen MacArthur Foundation in 2010 (Uwuigbe et al., 2025) that codified major CE principles. It was subsequently institutionalised, with the EU CE Action Plan and China CE Promotion Law. Digitalisation, regulatory change, consumer demand and green finance are the factors that drive CE today, and they can have major implications for the functioning of various sectors. Since sustainability is being established as an economic necessity, CE is becoming a holistic approach towards balancing growth and environmental care.

Figure 1: CE and the United Nations Sustainable Development Goals (SDGs)



Source: Velenturf and Purnell (2021).

Legend: Segment of targets under each goal would be moderately (dark grey) and strongly (black) enabled by execution of CE instruments.

1.3 Research Objectives and Significance of the Study

Nevertheless, regardless of the international trend, Pakistan does not have a unified body of research on the potential of localising the CE practices and incorporating them into national industrial policies. Much of the literature is still international centred with little being done in terms of applicability in the Pakistani economic, ecological and social environment. A theoretical gap also exists in the knowledge of how CE can improve industrial competitiveness and resilience in low- and middle- income economies.

This research paper explores the possibility of CE as a strategic avenue for the inclusive growth of Pakistan. Its central aims are as follows:

1. Evaluate the present situation of CE implementation in Pakistan,
2. Examine the trends of CE and patterns of green investment on the global scale,
3. Find policy and regulatory barriers to CE adoption, and
4. Assess the applicability of global CE best practices to the Pakistani context.

The sectors that are targeted in the study include waste management, construction, textiles, and agriculture since they are prepared to undergo CE transformation. It also discusses how CE may enhance social equity, local entrepreneurship, and economic resilience. The mechanisms of the EU's Global Gateway, the European Fund for Sustainable Development Plus (EFSD+), and the Green Climate Fund (GCF) are examined to understand how these instruments can support and facilitate Pakistan's transition towards a CE.

Climate vulnerability, pollution, and resource inefficiency are major issues that a country faces, and CE provides a revolutionary alternative. It is in line with the national priorities expressed in 'Vision 2025', 'Vision 2030', the '5Es Framework' and '*Uraan* Pakistan', which support sustainability, exports and climate-smart growth. Nevertheless, although policies like the 'Textile and Apparel Policy, 2020-2025' promote energy efficiency, they do not address CE explicitly, which shows the necessity of a specific and multi-level CE strategy that is integrated across both ministerial and broader governance frameworks.

2. LITERATURE REVIEW

The conventional linear economy model of 'take, make, dispose' has played a major role in environmental degradation, fast depletion of limited natural resources and escalating global climate change. By contrast, the circular economy (CE) offers a regenerative approach that seeks to minimise waste generation, maintain the continuous circulation of resources, and promote the design of systems that are sustainable in the long term. Globally, there is growing momentum around CE, with major economies such as the EU, China, and Japan integrating circularity into their industrial policies and governance frameworks (Velenturf and Purnell 2021, p. 2). Other cities like London, Tokyo and Melbourne are also welcoming CE as a pillar of sustainable urban development. In 2013, more than one-third of all global CEOs interpreted CE as a strategic opportunity that matched economic,

ecological, and ethical goals (Lew and Van de Perre 2024, p. 30).

The argument of CE adoption is backed by strong macroeconomic facts. It is estimated that the global circular economy would add up to USD 4.5 trillion to the global economy by 2030 (Chabowski et al., 2023, p. 2), particularly in industries with high costs of material inputs. As a point of reference, the world economy was estimated to be approximately USD 80 trillion in 2017 (Semertzidis 2022). Other than economic benefits, CE also provides environmental benefits. It is estimated that extensive use of CE can decrease greenhouse gas emissions by 63% by 2050, in case it is combined with low carbon technologies and efficient use of resources (Velenturf and Purnell 2021, p. 2).

Although the interest in CE is increasing internationally, developing nations are still underrepresented in the academic and policy discourse on CE, such as Pakistan. Much of the current literature focuses on developed economies, with a significant research gap on how CE can be adjusted to the settings that are characterised by institutional fragility, informal sectors, and capital shortage. The theoretical approaches to CE are more focused on innovation systems, lifecycle thinking, and circular design, but their relevance to the context of such countries as Pakistan, where informal waste economies and fragmented regulations dominate, has not been fully explored. The present paper is aimed at filling this theoretical gap by looking into the specific limitations and possibilities of the industrial and environmental situation in Pakistan.

The adoption of CE is fraught with some serious obstacles in Pakistan. These are low awareness of policymakers, poor institutional coordination, poor recycling and waste management infrastructure, and lack of circular financing mechanisms (Anjum et al., 2021, p. 1). Nevertheless, recent reports indicate that there is a potential to open the door to green entrepreneurship, local innovation as well as inclusive growth by overcoming these barriers. According to Baldassarre and Carrara (2025), CE integration might increase competitiveness of domestic industries by decreasing the use of imported raw materials, encouraging resources to be used efficiently, and creating jobs, particularly in recycling, remanufacturing, and eco-design industries. These changes in structure are compatible with Pakistan's objectives of economic diversification.

Case studies show how strategic public policies and investments in infrastructure have supported the success of CE. The EU, to illustrate, has pledged to attain a recycling rate of 55% by 2030, but analysts emphasise that better product design and waste collection systems are necessary to reach this goal (Antonopoulos et al., 2021, p. 1). Japan, where waste governance and municipal recycling are highly developed, has already reached soaring rates of resource circularity, with Kamikatsu reaching 80% recycling success (Herrador 2023, p. 1). In China, CE strategies introduced in more than 100 pilot cities have resulted in a 15 % decrease in waste production in core industrial sectors, including steel, cement, and textiles (Huang et al., 2021, p. 4).

Nevertheless, little has been said in terms of how these models can be applied to other

countries such as Pakistan where cost of production, lack of energy efficiency and innovation are some of the factors that undermine competitiveness of industries. When used properly, CE may become a policy lever of competitiveness, allowing industries such as agriculture, textiles, and construction to modernise their production processes, access green funds, and join global value chains as they become increasingly focused on sustainability indicators. Therefore, CE cannot be considered just an environmental solution rather an industrial transformation agenda.

3. METHODOLOGY

The paper uses qualitative, exploratory research design, which combines the desk review approach, comparative policy analysis, and case study synthesis methods to consider the potential of CE practices in Pakistan. The aim is to come up with context-specific insights through triangulation of global best practices, regional policy frameworks, and sectoral strategies within the socioeconomic and environmental situation of the country.

3.1 Desk Review

The desk review method was selected because the study focuses on policy frameworks, strategic documents, and cross-national practices, all of which can be effectively examined through secondary data sources. According to Bowen (2009), desk reviews are particularly useful when there is a need to synthesise a substantial body of existing knowledge in order to identify patterns, policy gaps, and opportunities for reform. The analysed literature consists of:

- CE theory and applications and new models in academic journal articles.
- Policy documents at a national and international level such as ‘Pakistan Vision 2025’, ‘EU Circular Economy Action Plan’, and China’s ‘Circular Economy Promotion Law.’
- Multilateral body reports including those of the World Bank, the United Nations Environment Programme (UNEP), the Ellen MacArthur Foundation, and the World Economic Forum.

These sources were coded and classified systematically according to their thematic areas like policy frameworks, sectoral applications, governance structures and investment mechanisms.

3.2 Comparative Policy Analysis

The study adopted a comparative policy analysis strategy to evaluate the structure, scope, and effectiveness of CE policies in countries of interests, mainly the EU, China, and Japan and how they can be applicable in Pakistan. Under this approach, it has been possible to identify:

- Common patterns of policy design and regulatory tools,
- Implementation challenges discrepancies,

- Portable governance and incentives strategies.

Howlett and Cashore (2014) state that comparative policy analysis is a legitimate approach to the study of how outcomes of policy are influenced by different institutional environments. The countries were chosen by their leadership in terms of innovation in CE policies, variety in economic structure, and the availability of longitudinal policy data.

3.3 Case Study Selection

Case studies of specific sectors were also analysed to give practical examples of CE in the most important sectors including agriculture and textiles, waste management, energy, and mining. Purposeful sampling was used to select the cases and priority was given to the examples with:

- Evidence of CE effect (environmental or economic outcomes that can be quantified),
- Applicability to the Pakistani industries, and
- Peer-reviewed or institutional publication documentation.

Specific corporate case studies (e.g. interface flooring, Unilever closed loop packaging) and city scale models (e.g. Kamikatsu in Japan, Amsterdam CE transition strategy) were aanlysed.

3.4 Interviews and Expert Validation

Expert interviews were not a major way of data collection in the research and are not formally analysed here. Informal consultations with CE practitioners and policy analysts were, however, carried out in the process of collecting data to guide case selection and validate the emerging themes. These were unstructured and exploratory consultations and are not referred to as empirical data and were used to provide contextual insights and interpret secondary findings.

3.5 Analytical Framework

The research used the thematic analysis method, which extracted patterns and common issues in CE models in other parts of the world. These themes were subsequently considered in terms of their relevance to the policy environment in Pakistan with special attention to readiness on an institutional level, regulatory gaps, financial mechanism and industrial fit. The findings provide a basis for developing evidence-based policy recommendations focused on Special Economic Zones (SEZs) in Pakistan and other industrial corridors that hold potential for advancing circularity.

4. ANALYSIS

The study notes that despite the fact that Pakistan's population produces solid waste of about 30 million tonnes a year, less than 10% is recycled, which is large unexploited potential in terms of CE practices (World Bank 2020). Comparatively, Germany has a recycling rate of about 67% of its waste, while Japan recycles approximately 20 % of its

raw materials (OECD 2021; METI 2020). This highlights the necessity of systemic CE integration in Pakistan. Implementing circular economy models, Pakistan can decrease environmental degradation, generate more than 200,000 green jobs (Slater et al., 2022), and open new business opportunities, especially in the agriculture, textile, mining, and energy sectors.

As an example, it has been estimated that the use of agricultural waste in Punjab and Sindh to generate compost and biofertilizers would reduce the importation of fertilizers by 30% and encourage regenerative agriculture (Rashid and Gani 2025). In the same way, pilot textile recycling programmes in SEZs such as Allama Iqbal Industrial City have demonstrated the ability to create a USD 500 million annual circular textiles economy (Sulaiman 2024). The practices do not only minimise environmental degradation but also enhance industrial competitiveness.

Being in line with global CE trends may also bring billions of foreign green investments, especially those located in SEZs that provide facilities to convert waste to value. Barral (2024) notes that between 2018 and today, more than USD 4 billion in green investment has been made in CE-based SEZs in such emerging economies as Vietnam and Indonesia. By 2030, in case, Pakistan adopts CE in full, the country will be able to reduce carbon emissions by 30% and increase GDP by 3-4% (Rodriguez et al., 2023). Thus, the implementation of the principles of CE is not only a green issue, but also an economic one.

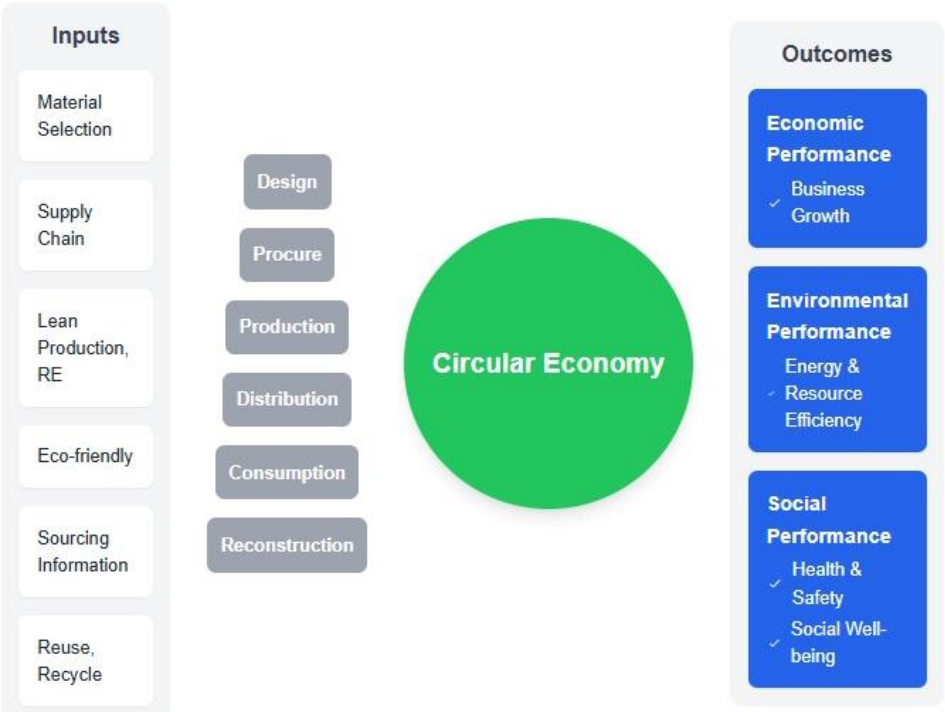
4.1. Advantages of a Circular Economy

CE's advantages can be generally divided into three categories: economic, environmental, and social:

a. Environmental Benefits: One of the greatest benefits of CE is that it decreases wastage by promoting recycling, reusing, and maximising the use of resources. Rather than discarding things, CE supports transforming waste into new materials, extending the life span of products, and saving the environment (Chen et al., 2022, p6). It also reduces greenhouse gas emissions through reduced energy-intensive manufacturing, extraction of raw materials, and shipping. Through adopting closed loop procedures, sustainable packaging, and remanufacturing, a circular economy can decouple industrial emissions and contribute substantially to combating climate change (Yang et al., 2023).
b. Economic Benefits: Converting to a CE can actually be advantageous to companies, industries, and even nations economically. By recycling materials, using energy more efficiently, and making supply chains smoother, businesses can cut down on manufacturing costs. Eco-friendly designs and closed loop manufacturing not only help save money but also help companies meet sustainability goals and cater to customers wanting greener products (Khan et al., 2024, p.3). Plus, sectors like waste management, recycling, remanufacturing, repairing, and refurbishing see new job opportunities for both skilled workers and those just starting out. CE also sparks innovation and healthy competition since companies are encouraged to develop new tech, sustainable

materials, and more efficient manufacturing methods. For example, American car makers save around USD 1 billion every year by recycling parts instead of making new ones. In China, CE policies have created over 30 million green jobs in areas like waste management, e-waste recycling, and sustainable manufacturing (Linnenluecke 2022, p.5).

Figure 2: Flow of Circular Economy Practices towards Economic, Environmental and Social Gains



Source: Authors' own.

c. Social Benefits: Aside from helping the environment and saving money, CE also brings important social benefits. For example, reducing waste, controlling pollution, and cutting down industrial emissions can lead to healthier communities and fairer chances for everyone. One of the biggest perks of these efforts is better health for the public. By lowering emissions, circular economy practices help decrease the risks of respiratory problems and water-related illnesses, which really makes a difference in people's lives (Neale et al., 2021, p. 24). The UN Environment Programme (UNEP) even estimates that adopting CE policies could save around 3 million lives worldwide by cutting down pollution-related diseases. Plus, it encourages comprehensive growth by opening chances for marginalised groups to get involved in upcycling, waste management, and recycling projects.

4.2. Best Practices of Circular Economy in Cities

a. Austin, Texas, is an example of using progressive approaches to achieving a zero-waste objective with the innovative web-based tool, called 'Materials Marketplace', which promotes industrial symbiosis by allowing companies to exchange resources and materials in the most efficient way (Bryan 2023). Such a platform, in combination with policies that require recycling infrastructure in both residential and commercial buildings, has created a collaborative environment supportive of circularity.

b. Shenzhen, China, has become a leader in circular urban mobility, with 16,000 diesel buses being replaced with electric vehicles and with significant investments in complete charging infrastructure (more than 500 charging sites and 5,000 charging points) (Shah 2024). The leasing model that allows e-buses to operate longer by swapping the drivetrain and battery has resulted in the decrease of particulate matter emissions by more than 4 million tonnes a year and a 40% drop in greenhouse gas emissions per kilometre (Li et al., 2022). Although the energy mix that is being used to power these buses is still mainly non-renewable, the efforts made by Shenzhen are in line with the overall trends of urban sustainability transitions observed in the recent literature (Seto 2023).

c. Toronto, Canada, implemented an extensive Circular Economy Procurement Plan to reduce the amount of waste, promote economic growth, and social well-being (Rajaonson and Chembessi 2024). Among the quantifiable effects, it has a great diversion of landfills, reduction of CO_2 emissions, as well as additional purchases of recycled materials. The plan's emphasis on social dimensions such as job creation and asset distribution initiatives is in line with the social justice models discussed in the CE literature (Geissdoerfer et al., 2017). Toronto represents the possible ways cities can incorporate circular principles into their public sector operations.

Table 1: Comparison of Global CE Policies

Country	Key Policies	Achievements	Challenges
Vietnam	National Action Plan on CE (2021)	Increased recycling rates	Limited enforcement
India	National Efficiency (2019)	Resource Policy	Focus on e-waste management
China	Circular Promotion (2008)	Economy Law	Established CE demonstration zones
Türkiye	Zero Waste Project (2017)	Reduced landfill waste	Limited public awareness
Germany	Circular Act (2012)	Economy	High recycling rates (67%)
Pakistan	Draft National Solid Waste Management Policy (2020)	Pilot projects in major cities	Lack of comprehensive framework

Source: Authors' own compilation.

4.3. Sectoral Best Practices of Circular Economy

a. Textiles Case: A closed loop supply chain is proving to be highly effective as a sustainable textile manufacturer takes post-consumer clothing and scraps of production materials and spins them into new fabrics and clothing. This project prevented 250 kilograms of textile waste being disposed of to the landfill, generating 50 T-shirts and 50 metres of woven fabric out of recycled fibres (Maitre-Ekern 2021). This was a project that needed a capital investment of USD 5 million in order to set up a domestic recycling plant, with government procurement contracts to provide hospital scrubs and prison uniforms among others guaranteeing steady revenues. The funding was achieved with the combination of venture capital, government subsidies, and Public-Private Partnerships (PPPs), which is characteristic of the complex investment strategies that are vital in scaling circular textile ventures (Geissdoerfer et al., 2017). This case highlights the importance of combining economic mechanisms and regulatory systems to promote sustainable resource consumption in historically high-waste sectors.
b. Organics Case: A recycling business of organic waste expanded to recycle more than 1,000 tonnes of organic waste, such as 300 tonnes of soil and 700 tonnes of green waste, into soil conditioners that restored 250 hectares of soil (Chen et al., 2022). The company's business model adopted a product-service system (PSS) approach, which combined product sales with on-site waste processing services for farms. Reverse logistics incentives and access to carbon credit markets served as diversified sources of revenue. A capital investment of USD 1.5 million was put into modern equipment. Although the firm faced obstacles such as initial investments and regulatory issues related to carbon credits, a Pay-As-You-Go (PAYG) model supported stable cash flow when expanding operations. This method shows how crucial the combination of technology, finance, and policy is in facilitating circular solutions in the organics industry (Kirchherr et al., 2023).
c. Construction Case: A timber manufacturing business that had a twenty-year track record sought to achieve net-zero waste targets through upcycling timber offcuts and recycling packaging. The company adopted lean production practices and redirected 11 to 15 skip bins of waste materials per week with 83% of timber waste being recycled (Marrucci et al., 2021). A new waste-sorting system resulted in a 40% decrease in operational waste and repurposed timber components resulting in an estimated 8% boost in annual revenue. This investment strategy involved equipment leasing of plastic baler to cover the cost of waste disposal by recycling rebates. The capital expenditures of USD 500,000 to 1 million were offset with cost-sharing with waste recycling contractors. Cooperation across the supply chain was essential, as such partnerships enable the sector to maintain circular production and advance CE (Ehrenfeld and Gertler 1997).

4.4. Best Practices of Circular Economy by Private Sector

Several global corporations have integrated CE principles into their core business models, demonstrating how innovation grounded in sustainability can drive and reshape global markets (Schultz et al., 2022). IKEA (Sweden) aims to achieve complete circularity by 2030, prioritising the design of reuseable products and integrating renewable energy in its supply chain (Bouhia 2022). Unilever (Global) will ensure that 50% of its virgin plastic reliance is reduced by 2025 by recycling and using alternative materials to reduce plastic pollution and create integrated packaging solutions (Linnenluecke 2022). Apple (USA) has the 'Daisy' recycling robot, which can be used to disassemble iPhones to reclaim precious metals, including gold and cobalt, demonstrating the importance of technological innovation in electronic waste reductions (Hassan and Vijayasingam 2023). These examples are evidence of the integration of resource optimisation and long-term economic development in corporate strategies, diminishing the environmental footprints and enhancing competitiveness.

Winnow uses image recognition metres powered by AI that examines the restaurant kitchen trash and links it with the sales data to change operational habits. This has seen waste reduction of up to 70% and USD 25 million annual savings in over 1000 locations which has shown that digital tools allow accurate circular interventions in food services.

Hyla Mobile breathes new life into about 50 million mobile devices by repurposing and reusing components, bringing in USD 4 billion, and avoiding 6,500 tonnes of e-waste entering landfills. Brazil-based eStoks refurbishes half of the broken electronics and fixes a quarter of them, ensuring that high-end electronics become available to the lower-income consumers, whereas CoreCentric focuses on bigger electronics and provides such services as remanufacturing and product returns management. The fact that they have recovered millions of parts and products is an example of the scalability of circularity that can be done based on the targeted product lifecycle management.

Kaer (Singapore) has transformed the air-conditioning market by offering their proprietary solution, the so-called AC as a Service (ACaaS), where the design, installation, and maintenance of the systems are handled by the company and monitored with the help of IoT to achieve maximum efficiency, saving up to 70% of energy cost. Schneider Electric integrates leasing and pays-per-use to enhance recovery of recyclable resources to 95% in 200 locations with no waste to landfill. These services, enabled by digital technologies, combine resource efficiency with innovative business models, showcasing the potential of CE within the service industries.

4.5. Developing a Pipeline of Investible Projects in Pakistan

Given the above literature review and use cases, CE has enormous potential to revolutionise the conventional sectors of Pakistan through waste-to-resource conversion, efficiency, and sustainable innovation. There are a number of industries that would benefit:

a. Agriculture: Being a prime economic pillar, agriculture generates lots of organic waste that can be used in composting and production of biofertilizers. Such technologies as pyrolysis systems and AI-based precision farming enhance inputs utilisation and productivity and minimise environmental damage (Chen et al., 2022). Smart irrigation and drone surveillance investment seals the gap between the past and the future.
b. Textiles: The textile industry is notorious for its ecological footprint and circularity can be implemented by recycling clothes and scraps into new materials (Maitre-Ekern 2021). Moreover, water consumption can be substantially reduced through innovations such as supercritical CO_2 dyeing and digital printing, which integrate sustainable processes with textile craftsmanship.
c. Mining: Mining waste can be repurposed through new extraction methods that recover valuable metals such as copper, gold, and rare earth elements, effectively transforming waste into a resource (Gaustad et al., 2021). Recovery units can be set up through investor-industry partnerships that are in line with global sustainability trends.
d. Industry: Industrial symbiosis converts waste into inputs across industries, e.g., steel slag in cement (Kirchherr et al. 2023). The use of biodegradable materials, sustainable packaging, and zero-emission goals is an indication of the move towards green manufacturing, which attracts investor interest (Marrucci et al., 2021).

4.5.1. Circular Economy in Special Economic Zones (SEZs)

Industrial symbiosis is particularly effective within Special Economic Zones (SEZs), where geographic proximity enables the sharing of resources, valorisation of waste, and major cost savings. As an example, food processing byproducts may be transformed into farm compost or bioenergy, and excess heat in steel plants may be utilised in textile drying processes, and the maximum utilisation of resources and minimum waste will be achieved (Hald-Mortensen 2025). This is the case with Kalundborg SEZ in Denmark and Suzhou Industrial Park in China and Ninh Bihn Industrial Zone in Vietnam where exchanges of byproducts have reduced the cost of production as well as landfills.

Special Economic Zones (SEZs) in Pakistan, including Rashakai and the Allama Iqbal Industrial City, could benefit from pilot programmes based on industrial symbiosis models. These initiatives could be further strengthened through the development of green infrastructure, such as energy-efficient buildings, renewable energy farms, and centralised waste management systems, thereby enhancing both economic productivity and environmental sustainability (Bressanelli et al., 2022). This type of integration confirms that the advancement of CE practices does not have to abandon industrial progress rather, can take it into a sustainable tomorrow.

4.6.Global Funding Avenues

The process of green economies taking place throughout the world is directly connected to the principles of CE. The Sustainable Development Goals (SDGs) and the Paris Agreement are international frameworks that focus on resource efficiency and waste reduction as a

crucial part of climate resilience and sustainable development (Maitre-Ekern 2021). Economies will be forced to switch to sustainable practices or lose a competitive advantage in the global market in the near future due to the existence of regulatory mechanisms, including the EU Carbon Border Adjustment Mechanism (CBAM).

This transition cannot be made without strong investment and collaboration with other countries. The Green Climate Fund (GCF) is a major fund globally that supports climate-resilient and renewable energy projects in developing nations through loans, grants, guarantees, and equity investments (Sharma et al., 2021). The same is true of the Global Environment Facility (GEF) which offers grant programmes that can be used to facilitate sustainable production and consumption, especially for infrastructure, manufacturing, and agricultural sectors that seek to become circular.

Circular Economy 100 (CE100) is an initiative of the Ellen MacArthur Foundation that brings governments and companies together to develop sustainable manufacturing and packaging innovations through joint knowledge and funding opportunities. Global platforms like the World Circular Economy Forum (WCEF) and United Nations Climate Change Conferences (COP) are important avenues to share success stories, create partnerships and mobilise global capital to the circular economy agenda (Barua 2020).

By intelligently aligning policies, investments, and partnerships, Pakistan and the global community can accelerate the transition towards a circular economy, making sustainability not a distant aspiration but a shared and achievable reality.

5. POLICY RECOMMENDATIONS FOR PAKISTAN

The future of a circular economy in Pakistan can be founded on five pillars, including smart policy, resilient infrastructure, informed citizenry, global financing, and public-private synergy:

a. The transformation of Pakistan to a circular economy is not a simple reform, it requires a systematic change at the policy, education, financial, technology, and cooperation levels. The country can realise the full potential of circularity only through the development of an integrated ecosystem. The foundation is a consistent national policy, with realistic and realistic targets, sustainable production and responsible consumption. It is supposed to contain eco-design requirements, green procurement incentives, Extended Producer Responsibility (EPR) initiatives, and waste-to-energy pilot projects. Such a policy will need to be developed between the government, industry, academia and civil society in a concerted effort to strike a balance between environmental and economic interests.
b. Good policy requires good infrastructure. Modern waste management, waste sorting, recycling and upcycling should be invested in. Industrial symbiosis ought to be promoted in SEZs by converting waste into resource flows. The physical structure of circularity can be linked through reverse logistics networks in which products may be

collected and reprocessed.

c. There can be no successful implementation of policies and plans without the active understanding and engagement of people and institutions. CE literacy in Pakistan should be promoted through targeted awareness campaigns, industry workshops, and educational reforms. The integration of circular economy concepts into school curricula and the development of pilot projects in key sectors such as textiles and agriculture will help translate this vision into reality. Furthermore, waste management, sustainable design research, and technology development can be advanced through the establishment of a Circular Economy Innovation Hub.
d. Critical capital and expertise can be offered by global financial instruments (like Green Climate Fund, GEF and European Circular Economy Funds). Government matchmaking, green bond promotion, and global forums are critical in facilitating strategic alliances with international companies and development agencies to scale circular initiatives.
e. Teamwork creates impetus. PPPs combine the power of public control and funding with the power of innovation and efficiency of the private sector. Using the examples of other countries, such as industrial clusters of China, recycling in Germany, and pilot programmes in Vietnam, Pakistan can develop its own ecosystem. Collaboration can be institutionalised by means of national and provincial Circular Economy Business Councils that can drive market growth.

6. CONCLUSION

This research was aimed at discussing whether a Circular Economy (CE) could be an effective strategic framework towards the achievement of sustainable and equitable development in Pakistan. The presented evidence proves that CE has multidimensional advantages: environmental ones due to the decrease in emissions and waste, economic ones with the increasing productivity and innovation, and social ones with the creation of jobs and improvement of equity. The model offers a good opportunity to Pakistan to decouple economic growth with environmental degradation and resource depletion. Through global success stories and best practices, in particular manufacturing, mining, textile, agriculture and energy, Pakistan can customise and execute effective CE strategies that are appropriate to its own socioeconomic environment.

Nevertheless, to achieve this potential, a national CE strategy that is coordinated and supported by sound policies, sustainable financing, infrastructure investments, and capacity building is necessary. Addressing the most serious obstacles, including the lack of awareness among stakeholders, obsolete regulations, and underdeveloped waste management systems, will also require the use of international partnerships, the adoption of advanced technologies, and the development of effective PPPs.

It is crucial to incorporate CE principles into the overall developmental agenda of Pakistan in order to make the country a regional leader in green industrial development. The

roadmap in this study provides policy makers, companies and investors with practical suggestions to facilitate this transition.

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