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REVIEW ARTICLE

Circular Economy for Sustainable Business Transformation: A Review of Strategies, Implementation Challenges, and Environmental Benefits

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Abstract

The circular economy (CE) has emerged as a transformative approach to advancing sustainable business management by promoting resource efficiency, waste minimization, and value retention across production and consumption systems. This review synthesizes current research on circular economy strategies, organizational and institutional drivers, implementation barriers, and associated environmental implications. It examines key circular business practices, including eco-design, resource recovery, reuse, repair, remanufacturing, recycling, industrial symbiosis, and product-service systems. Particular attention is given to the technological, financial, organizational, regulatory, and supply-chain factors that influence the adoption and effectiveness of these strategies. The review also evaluates their potential environmental outcomes, including reduced greenhouse gas emissions, improved resource efficiency, waste prevention, and pollution mitigation, while recognizing potential trade-offs and rebound effects. Furthermore, it explores the role of digital technologies, policy frameworks, stakeholder collaboration, and organizational innovation in accelerating circular transitions. Based on the synthesized evidence, an integrated conceptual framework is proposed to connect circular economy strategies, implementation conditions, and environmental performance. The review identifies critical research gaps and outlines future directions for strengthening circular business models and integrating circularity into sustainable business management. These insights provide valuable guidance for researchers, policymakers, and business practitioners seeking to advance environmentally responsible and economically viable circular transitions.

Keywords: Circular economy; Sustainable business management; Circular business models; Implementation barriers; Environmental sustainability

1. Introduction

The increasing consumption of natural resources, growing waste generation, environmental degradation, and climate change have intensified the need to transform conventional economic and industrial systems. The traditional linear economic model, commonly described as a take–make–dispose approach, depends on extracting virgin resources, manufacturing products, distributing them to consumers, and discarding materials after use. Although this model has supported industrial development and economic growth, it has also contributed to resource depletion, waste accumulation, pollution, and increasing environmental pressures.

Consequently, alternative approaches that improve resource productivity and minimize environmental impacts have become increasingly important for businesses and policymakers (Ghisellini et al., 2016; Geissdoerfer et al., 2017). The circular economy (CE) provides an alternative framework for addressing these challenges by maintaining the value of products, components, and materials within economic systems for as long as possible. It emphasizes reducing resource consumption, extending product lifetimes, promoting reuse and repair, recovering valuable materials, and minimizing waste generation. Rather than treating waste as an unavoidable endpoint of production and consumption, circular approaches consider waste and residual materials as potential resources for subsequent production processes (Kirchherr et al., 2017). Accordingly, the CE represents a broader transformation of production systems, consumption patterns, business models, and resource management practices.

The relationship between circular economy principles and sustainable development has received considerable attention in academic research. Geissdoerfer et al. (2017) highlighted the conceptual relationship between circular economy and sustainability, emphasizing that circularity can contribute to sustainable development but should not automatically be considered equivalent to sustainability. Similarly, Kirchherr et al. (2017), through an analysis of 114 circular economy definitions, demonstrated that the concept encompasses multiple dimensions, including resource efficiency, waste reduction, economic prosperity, and environmental quality. Their findings also highlighted the importance of adopting a systemic perspective rather than reducing circular economy implementation to recycling activities alone. Businesses are particularly important in translating circular economy principles into practical sustainability outcomes. Corporate decisions concerning product design, material selection, production technologies, supply chain management, packaging, distribution, and end-of-life management influence the quantity of resources consumed and the environmental impacts associated with products and services. Consequently, integrating circular principles into business management can support operational efficiency, reduce dependence on virgin materials, improve resource productivity, and create opportunities for new revenue streams and innovative business models (Bocken et al., 2016; Lüdeke-Freund et al., 2019).

Circular economy strategies also provide opportunities to reconsider conventional approaches to value creation. Instead of relying exclusively on increasing product sales and material throughput, organizations can develop business models based on product durability, repair services, leasing, sharing, refurbishment, remanufacturing, and material recovery. These approaches can generate economic value while reducing material losses and improving resource utilization. However, their effectiveness depends on the characteristics of products, consumer preferences, technological capabilities, market conditions, and the availability of reverse logistics infrastructure (Bocken et al., 2016; Centobelli et al., 2020).

Despite these opportunities, the transition toward circular business practices remains challenging. Many organizations experience financial constraints, inadequate recycling and recovery infrastructure, limited access to appropriate technologies, regulatory uncertainty, and difficulties coordinating activities across supply chains. Small and medium-sized enterprises (SMEs) can face particularly substantial implementation challenges because of limited financial resources, insufficient technical expertise, and restricted access to specialized infrastructure (Rizos et al., 2016). Furthermore, organizational resistance, conventional performance measurement systems, and uncertainty regarding the profitability of circular investments can discourage businesses from adopting circular strategies (Sarja et al., 2021; Hina et al., 2022).

Another important consideration is that circular economy implementation does not necessarily guarantee positive environmental outcomes. Although reuse, recycling, remanufacturing, and resource recovery can reduce environmental pressures, their benefits depend on the energy and material requirements of recovery processes, transportation distances, product substitution effects, and the environmental characteristics of

alternative materials. Zink and Geyer (2017) demonstrated that circular activities can generate rebound effects when reduced production costs or improved resource efficiency stimulate additional consumption. Similarly, Korhonen et al. (2018) emphasized that the circular economy faces physical and thermodynamic limitations that must be considered when evaluating its environmental sustainability. Although existing studies have examined circular economy business models, organizational barriers, and environmental implications, the evidence remains distributed across different research areas. Some studies emphasize business model innovation, whereas others focus on manufacturing, supply chain management, resource efficiency, or environmental assessment. Integrating these perspectives is important for understanding how circular strategies can be implemented effectively and how their organizational and environmental outcomes are interconnected.

Against this background, this review examines circular economy strategies for sustainable business management through three interconnected objectives: (1) identifying the principal circular economy strategies and business practices adopted by organizations; (2) evaluating the major barriers and enabling factors influencing their implementation; and (3) examining their environmental implications, including potential benefits, limitations, and trade-offs. The review also develops an integrated conceptual framework and identifies future research priorities to support the transition toward more sustainable and resource-efficient business systems.

2. Methodology

This review adopts a structured systematic literature review approach to synthesize research on circular economy strategies, sustainable business management, implementation barriers, enabling factors, and environmental implications. The methodological design draws on established systematic review procedures and the PRISMA reporting framework, which provides guidance for documenting literature identification, screening, eligibility assessment, and inclusion decisions, thereby improving transparency and reproducibility.

2.1. Literature search strategy and selection criteria

The literature search focuses on peer-reviewed publications addressing circular economy implementation within business organizations, industrial systems, and sustainable supply chains. Scopus and Web of Science are appropriate primary databases because they provide extensive coverage of interdisciplinary research in environmental science, engineering, sustainability, operations management, and business studies. Google Scholar was also used as a supplementary source for identifying relevant publications and checking cited references. The search strategy combines keywords related to circular economy, business management, sustainability, implementation barriers, enabling factors, and environmental performance. Representative search terms include "circular economy" AND "business management", "circular business models" AND "sustainable business", "circular economy implementation" AND "barriers", "circular economy" AND "drivers" OR "enablers", "circular supply chain" AND "sustainability", "circular economy" AND "environmental performance", "resource efficiency" AND "business sustainability", and "circular economy" AND "life cycle assessment".

The search prioritized peer-reviewed journal articles published between 2012 and 2023, while retaining earlier seminal publications when necessary to establish theoretical foundations and explain the development of circular economy concepts. Relevant systematic reviews, conceptual studies, empirical investigations, and life-cycle assessment studies were considered. Studies were considered eligible when they examined at least one of the following themes: circular economy strategies in organizations, circular business models, corporate

implementation barriers, organizational or institutional enablers, sustainable supply chain practices, resource efficiency, waste minimization, or environmental outcomes of circular interventions.
Publications were excluded when they were unrelated to organizational or industrial circularity, provided insufficient methodological information, duplicated another publication, or focused exclusively on technical waste-treatment processes without relevance to business management or environmental performance.

2.2. Screening, data extraction, and evidence synthesis

The literature-selection process followed four principal stages: identification, screening, eligibility assessment, and final inclusion. First, records retrieved from the selected databases were compiled, and duplicate publications were removed. Second, titles and abstracts were examined to determine their relevance to the research objectives. Third, potentially relevant publications were evaluated through full-text assessment against the predefined eligibility criteria. Finally, eligible studies were included in the qualitative synthesis. Data extraction focused on publication year, geographical context, industrial sector, research methodology, circular economy strategies, identified barriers, enabling factors, and reported environmental implications. Particular attention was given to the relationship between organizational practices and measurable sustainability outcomes. The extracted evidence was synthesized using a thematic approach. Studies were grouped into three principal analytical categories: circular economy strategies in business management, implementation barriers and enabling factors, and environmental implications. The findings were compared to identify recurring patterns, differences across industrial contexts, and research gaps.
The selected literature is summarized in Table 1. The synthesis gave particular consideration to influential conceptual contributions and systematic reviews, including Ghisellini et al. (2016), Bocken et al. (2016), Kirchherr et al. (2017), Lüdeke-Freund et al. (2019), Sarja et al. (2021), and Hina et al. (2022).

3. Circular economy strategies in sustainable business management

Circular economy strategies provide organizations with practical approaches to reducing resource consumption, minimizing waste, extending product lifetimes, and maintaining the value of materials within production and consumption systems. Unlike conventional environmental management approaches that often emphasize pollution control or waste treatment, circular strategies seek to redesign products, production processes, business models, and supply chain relationships. Their implementation therefore requires integration across corporate strategy, operations, innovation, procurement, marketing, and environmental management (Ghisellini et al., 2016; Bocken et al., 2016).
A useful distinction is between strategies that narrow, slow, and close resource loops. Narrowing resource loops involves reducing the quantity of materials and energy required to deliver a product or service. Slowing resource loops extends product lifetimes through durability, maintenance, repair, reuse, and refurbishment. Closing resource loops involves recovering materials and components through remanufacturing, recycling, and other recovery processes. These strategies are complementary but differ in their environmental and operational implications (Bocken et al., 2016).

Table 1. Overview of influential literature on circular economy strategies in sustainable business management

Author(s)	Research focus	Main contribution
Ghisellini et al. (2016)	Circular economy concepts and transition	Examined CE principles, implementation approaches, and environmental and economic dimensions.
Bocken et al. (2016)	Product design and business models	Developed strategies for slowing, closing, and narrowing resource loops.
Kirchherr et al. (2017)	Circular economy definitions	Demonstrated the multidimensional nature of CE and the importance of systemic transformation.
Geissdoerfer et al. (2017)	CE and sustainability	Examined the conceptual relationship between circular economy and sustainable development.
Korhonen et al. (2018)	Environmental limitations of CE	Highlighted physical, thermodynamic, and systemic limitations of circularity.
Lüdeke-Freund et al. (2019)	Circular business model patterns	Identified six major patterns of circular business models.
Centobelli et al. (2020)	Circular business model design	Synthesized business model design approaches and research priorities.
Sarja et al. (2021)	Organizational transition	Identified obstacles, catalysts, and context-dependent implementation factors.
Hina et al. (2022)	Drivers and barriers	Synthesized major drivers and barriers to circular economy business model implementation.
Assmann et al. (2023)	Adoption determinants	Identified 54 determinants grouped into eight macro-categories.

3.1. Resource efficiency and sustainable production

Resource efficiency represents one of the most direct approaches to incorporating circular economy principles into business operations. It involves reducing the material, energy, and water requirements associated with manufacturing and service delivery while maintaining product quality and operational performance. Businesses can improve resource efficiency through process optimization, cleaner production technologies, material substitution, energy-efficient equipment, water recycling, and improved production planning.

Cleaner production practices can reduce material losses and pollution at their sources rather than relying exclusively on downstream waste treatment. For manufacturing organizations, this may involve redesigning production processes to minimize offcuts, improving material utilization, reducing defective products, and reusing process residues. These measures can simultaneously reduce operating costs and environmental pressures (Lieder and Rashid, 2016).

Industrial symbiosis provides an additional opportunity to improve resource efficiency by connecting organizations through exchanges of materials, energy, water, and by-products. Under this approach, the residual output of one industrial facility can become an input for another organization. Industrial symbiosis can reduce disposal requirements and virgin resource consumption while creating economic value from previously underutilized materials (Ghisellini et al., 2016).

However, the success of resource efficiency strategies depends on accurate monitoring of material and energy flows. Material flow analysis, resource productivity indicators, and environmental management systems can help organizations identify resource losses and establish measurable improvement targets.

3.2. Circular product design and life extension

Product design is central to circular economy implementation because many environmental impacts and end-of-life management requirements are determined during the early stages of product development. Products designed for durability, repairability, disassembly, modularity, and material recovery are generally better positioned to support circular business models. Bocken et al. (2016) emphasized the importance of product design and business model strategies for slowing and closing resource loops. Design for durability extends product lifetimes, while modular design allows individual components to be replaced without discarding entire products. Design for disassembly facilitates component recovery and material separation, improving opportunities for repair, refurbishment, and recycling.

Businesses can also introduce product take-back arrangements, maintenance services, repair programs, and refurbishment schemes. These approaches preserve the functional and economic value of products and components. For example, electronic equipment manufacturers can recover used products, replace damaged components, upgrade software, and resell refurbished equipment. Similarly, manufacturers of industrial machinery can provide maintenance and component-replacement services to extend equipment lifetimes. Product life extension can reduce demand for new production, although the actual environmental benefit depends on whether refurbished or repaired products genuinely displace the manufacture of new products. The environmental performance of life-extension strategies should therefore be evaluated against realistic alternative scenarios rather than assumed to be beneficial in every case.

3.3. Reuse, remanufacturing, and recycling

Reuse, remanufacturing, and recycling are important circular economy strategies for maintaining material and product value. Reuse involves using products or components again, either for their original purpose or for an alternative application. Remanufacturing involves restoring used products or components to a specified functional condition through inspection, disassembly, replacement, and reassembly. Recycling involves processing discarded materials into secondary raw materials. Lüdeke-Freund et al. (2019) identified repair and maintenance, reuse and redistribution, refurbishment and remanufacturing, recycling, cascading and repurposing, and organic feedstock business models as major circular business model patterns. These approaches provide different opportunities for retaining product and material value.

From a resource conservation perspective, reuse and remanufacturing can preserve more of the value embedded in products than material recycling, particularly when products contain complex components or require substantial energy and resources during initial manufacturing. Recycling remains important for materials that cannot be reused or economically recovered in their original form. Nevertheless, recycling quality, contamination, material degradation, and recovery efficiency influence its environmental effectiveness.

Businesses can strengthen these practices through reverse logistics, product-return systems, material recovery partnerships, and collaboration with specialized recycling organizations. However, effective implementation requires appropriate collection infrastructure, material traceability, quality standards, and stable markets for recovered materials.

3.4. Circular business models and product-service systems

Circular business models represent a fundamental transformation in how organizations create, deliver, and capture value. Instead of relying exclusively on the sale of new physical products, businesses can generate

revenue through services, access-based arrangements, leasing, sharing, maintenance, repair, and product recovery.

Lüdeke-Freund et al. (2019) demonstrated that circular business models can be organized into several recurring patterns, including repair and maintenance, reuse and redistribution, refurbishment and remanufacturing, recycling, cascading and repurposing, and organic feedstock models. These patterns illustrate how circularity can be integrated into corporate value propositions and revenue-generating activities.

Product-service systems are particularly relevant because they shift the business relationship from product ownership toward the provision of a service or functional outcome. For example, a manufacturer may provide lighting services rather than selling lighting equipment, or supply industrial machinery through leasing and performance-based service contracts. Under appropriate contractual arrangements, manufacturers retain responsibility for maintenance, upgrades, and end-of-life management, potentially creating incentives to design longer-lasting and more resource-efficient products. Sharing and collaborative consumption models can also improve asset utilization by enabling multiple users to access products that would otherwise remain underutilized. However, these models require effective demand management, maintenance systems, consumer acceptance, and suitable digital infrastructure.

The transition to circular business models can require substantial organizational changes, including new revenue structures, customer relationships, product ownership arrangements, and reverse supply chain capabilities. Consequently, business model innovation should be considered an integral component of corporate circular economy strategies rather than a supplementary environmental initiative (Centobelli et al., 2020).

3.5. Sustainable supply chain management and digital technologies

Circular economy implementation extends beyond individual organizations because material recovery, product returns, reuse, and recycling often require collaboration among suppliers, manufacturers, distributors, consumers, and waste-management organizations. Circular supply chain management integrates forward and reverse material flows to maintain product and resource value throughout the supply chain. Organizations can adopt sustainable procurement policies that prioritize recycled, renewable, recyclable, durable, and responsibly sourced materials. Supplier engagement can improve material traceability, encourage eco-design, and promote waste reduction across production networks. Reverse logistics facilitates the collection, sorting, repair, refurbishment, remanufacturing, and recycling of used products and materials.

Digital technologies can strengthen these activities by improving information exchange, product identification, resource monitoring, and supply chain coordination. Internet of Things (IoT) devices can monitor equipment condition and support predictive maintenance, while artificial intelligence can improve production planning, material sorting, and demand forecasting.

Blockchain and digital product records may support traceability and information sharing across complex supply chains, although their effectiveness depends on data quality, interoperability, governance, and implementation costs. These technologies should be considered enabling instruments rather than independent circular economy solutions. Their environmental value depends on whether improved information and coordination result in measurable reductions in resource consumption, waste, and environmental impacts.

Figure 1 presents the integrated conceptual relationship between organizational drivers, circular economy strategies, enabling conditions, and sustainable business outcomes. It emphasizes that circular business performance emerges from the interaction of corporate commitment, technological capabilities, supply chain collaboration, and supportive institutional conditions.

Overall, circular economy strategies can contribute to sustainable business management through resource efficiency, product life extension, material recovery, innovative business models, and circular supply chain integration. However, the effectiveness of these approaches depends on their coordination across organizational functions and their alignment with measurable economic and environmental objectives.

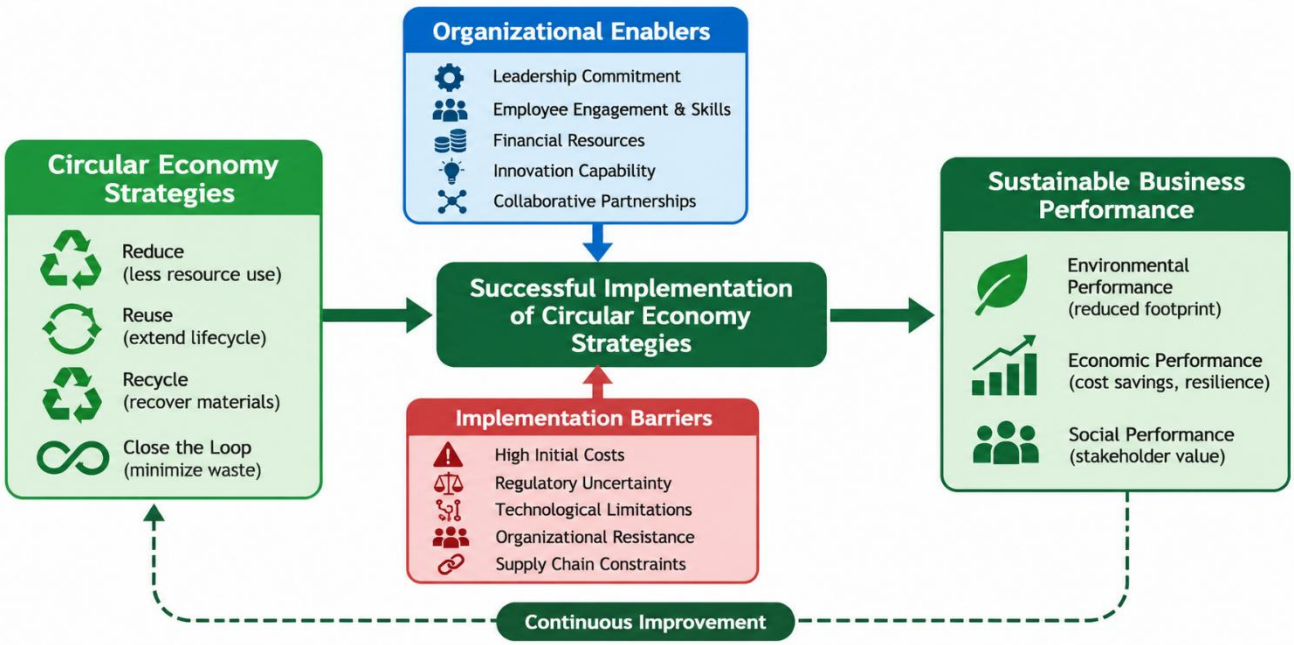


Figure 1. Integrated framework linking circular economy strategies, organizational enablers, implementation barriers, and sustainable business performance.

4. Implementation barriers and enabling factors

Despite the increasing recognition of circular economy principles, their practical implementation remains challenging for many businesses. The transition from linear to circular business practices requires changes in organizational structures, production systems, supply chain relationships, investment priorities, and consumer engagement. Existing studies indicate that implementation barriers and enabling factors are multidimensional and frequently interact with one another (Rizos et al., 2016; Sarja et al., 2021; Hina et al., 2022).

4.1. Financial and economic barriers

Financial constraints represent one of the most significant challenges to circular economy adoption. Establishing reverse logistics networks, installing advanced recycling equipment, redesigning products, developing digital tracking systems, and introducing remanufacturing facilities can require substantial initial investments. For many businesses, particularly SMEs, the expected financial benefits of circular investments may be uncertain or difficult to quantify. Circular business models can also involve longer payback periods than conventional production systems, especially when organizations must establish new customer relationships, collection networks, or product-service arrangements.

Market uncertainty further complicates investment decisions. Recovered materials may compete with relatively inexpensive virgin resources, while demand for refurbished and remanufactured products may fluctuate

depending on consumer preferences and product quality perceptions. These conditions can weaken the business case for circular investments. Access to green finance, targeted subsidies, low-interest loans, tax incentives, and public-private investment partnerships can help address these challenges. Financial institutions can also support circular transitions by incorporating resource efficiency and environmental performance into investment evaluation criteria.

4.2. Technological and infrastructural barriers

Circular economy strategies frequently depend on technologies and infrastructure that may be unavailable, expensive, or insufficiently developed. Recycling and remanufacturing require appropriate collection systems, sorting facilities, material-processing technologies, quality-control mechanisms, and reliable secondary material markets. Technical limitations can also restrict material recovery. Composite products, mixed materials, contaminated waste streams, and complex electronic components may be difficult to separate and recycle efficiently. Furthermore, some materials experience quality degradation during repeated recycling cycles, limiting their suitability for certain applications.

Digital technologies can improve circular operations, but their adoption may be constrained by limited technical expertise, high implementation costs, data integration challenges, and inadequate digital infrastructure. These barriers are particularly relevant to smaller organizations and businesses operating in emerging economies.

Investment in research and development, industrial infrastructure, technology transfer, technical training, and shared recycling facilities can improve the technological conditions required for circular economy implementation.

4.3. Organizational and managerial barriers

Organizational culture, managerial commitment, employee awareness, and strategic priorities strongly influence the adoption of circular practices. Businesses that continue to prioritize short-term production volumes, sales growth, and cost minimization may be reluctant to invest in business models that require long-term resource stewardship. Circular economy implementation often requires coordination across departments responsible for procurement, production, product development, logistics, marketing, finance, and environmental management. Fragmented decision-making can prevent organizations from integrating circular objectives into their overall business strategies.

Limited managerial knowledge and insufficient employee training can also reduce implementation effectiveness. Employees may lack the technical capabilities required for eco-design, material assessment, waste minimization, and circular performance monitoring. Strong leadership, cross-functional coordination, employee engagement, sustainability-oriented organizational culture, and clear corporate targets can help overcome these challenges. Circular economy objectives should be integrated into corporate strategies, operational procedures, performance evaluation systems, and investment decisions.

4.4. Regulatory and institutional barriers

Institutional conditions play a significant role in shaping business incentives and investment decisions. Unclear regulations, inconsistent environmental standards, inadequate enforcement, and fragmented waste-management policies can discourage organizations from adopting circular practices. Regulatory uncertainty may increase investment risks, particularly for businesses operating across multiple jurisdictions. In addition, insufficient

standards for recycled materials, product durability, repairability, and extended producer responsibility can limit market development and create uncertainty regarding product quality and compliance requirements.
Conversely, coherent environmental regulations can accelerate circular transitions by establishing minimum standards and encouraging resource-efficient production. Extended producer responsibility, landfill restrictions, recycled-content requirements, eco-design regulations, and public procurement policies can create incentives for businesses to redesign products and improve material recovery.
Policy effectiveness depends on regulatory consistency, enforcement capacity, stakeholder consultation, and alignment between environmental objectives and industrial development strategies.

4.5. Market, consumer, and supply chain barriers

Consumer acceptance is essential for the success of many circular business models. Although environmental awareness has increased, consumers may continue to prefer new products over refurbished alternatives because of concerns about quality, reliability, hygiene, warranties, or product appearance.
Price sensitivity can also limit demand for circular products when their initial prices are higher than conventional alternatives. Businesses may therefore experience difficulties establishing markets for reused, repaired, or remanufactured products. Supply chain fragmentation presents another challenge. Circular business models often require information sharing and cooperation among suppliers, manufacturers, distributors, consumers, and recovery organizations. However, organizations may be reluctant to share commercially sensitive information or assume responsibility for additional collection and recovery activities.
Supplier engagement, consumer education, transparent product information, quality certification, warranty arrangements, and collaborative supply chain agreements can improve market acceptance and coordination.

4.6. Enabling factors for successful implementation

The successful adoption of circular economy strategies depends on the interaction of organizational, technological, financial, institutional, and market-related enabling factors. Evidence from systematic reviews demonstrates that determinants of circular business model adoption extend across multiple organizational and external dimensions. For example, the review by Hina et al. (2022) identified a broad range of drivers and barriers, while Assmann et al. (2023) classified 54 determinants into eight macro-categories: culture, regulation, market, strategy, business case, collaboration, operations, and knowledge.
Managerial commitment is important because circular transformation requires long-term strategic direction and organizational coordination. Financial resources enable investment in circular technologies and infrastructure, while innovation capabilities support product redesign, process optimization, and new revenue models. Institutional support creates favorable regulatory conditions, and supply chain collaboration enables material recovery and information exchange.
Digital technologies and data-driven management systems can strengthen resource monitoring, product traceability, predictive maintenance, and reverse logistics. In addition, consumer awareness and market acceptance create demand for circular products and services, improving the commercial viability of circular business models.
Table 2 summarizes the major implementation barriers and corresponding enabling factors. The table demonstrates that circular economy adoption is not determined by a single organizational capability or policy intervention; instead, it requires coordinated action across multiple dimensions.

The synthesis indicates that barriers and enabling factors frequently operate simultaneously. For example, high investment costs can be reduced through policy incentives, shared infrastructure, and collaborative business arrangements. Similarly, technological limitations can be addressed through research partnerships, knowledge exchange, and access to specialized service providers. This suggests that isolated interventions are unlikely to produce comprehensive circular transformation.

Table 2. Major implementation barriers and enabling factors for circular economy adoption in business organizations

Dimension	Major implementation barriers	Enabling factors
Financial and economic	High initial investment, uncertain returns, limited access to finance, weak secondary-material markets	Green finance, subsidies, tax incentives, investment partnerships, viable circular business cases
Technological	Inadequate recycling technologies, limited technical expertise, material recovery difficulties	Research and development, technology transfer, advanced manufacturing, digital innovation
Organizational	Limited managerial commitment, resistance to change, inadequate employee skills, fragmented responsibilities	Leadership, employee training, organizational culture, cross-functional coordination
Regulatory and institutional	Policy uncertainty, inconsistent standards, weak enforcement, inadequate incentives	Clear regulations, extended producer responsibility, environmental standards, supportive public procurement
Market and consumer	Low acceptance of refurbished products, price sensitivity, limited awareness, uncertain demand	Consumer education, quality certification, warranties, circular product marketing
Supply chain	Fragmented networks, weak collaboration, inadequate reverse logistics, limited information sharing	Supplier partnerships, collaborative networks, product traceability, reverse logistics infrastructure
Knowledge and information	Insufficient circularity data, limited life-cycle information, weak performance monitoring	Digital product information, environmental assessment, material flow analysis, standardized indicators

Source: Synthesized from Rizos et al. (2016), Sarja et al. (2021), Hina et al. (2022), and Assmann et al. (2023).

5. Environmental implications and future research directions

Circular economy strategies are frequently promoted as approaches for reducing environmental pressures associated with conventional production and consumption systems. Their environmental implications extend across resource extraction, manufacturing, product use, transportation, waste management, and material recovery. However, the magnitude and direction of environmental outcomes depend on the characteristics of individual circular interventions and their broader life-cycle consequences.

5.1. Resource conservation and waste reduction

One of the principal environmental benefits of circular economy implementation is the potential reduction in virgin material consumption. Reuse, repair, refurbishment, and remanufacturing can extend the productive life of existing products and components, reducing the need for additional raw materials and energy-intensive manufacturing. Resource efficiency measures can also reduce production waste and improve material utilization. Industrial symbiosis and by-product exchange provide opportunities to recover materials that would otherwise be discarded, thereby reducing waste disposal requirements and increasing resource productivity.

Recycling can reduce demand for primary materials when secondary materials are of sufficient quality and effectively substitute for virgin inputs. Nevertheless, the environmental performance of recycling depends on collection efficiency, sorting requirements, processing energy, contamination, and material losses. Circular economy practices can also support improved waste management through product take-back programs, reuse networks, repair services, and recycling partnerships. These activities can reduce landfill disposal and promote more efficient material circulation.

5.2. Climate change mitigation and energy implications

Circular strategies can contribute to climate change mitigation by reducing demand for energy-intensive primary material production and manufacturing. Reusing products and components can avoid some of the energy requirements associated with extracting, processing, and manufacturing new materials. For example, remanufacturing may require fewer resources than producing entirely new products, depending on product design, component condition, and recovery requirements. Similarly, recycled materials may have lower production-related environmental burdens than virgin materials for certain material categories.

However, the climate benefits of circular practices are not uniform. Collection, transportation, sorting, cleaning, remanufacturing, and recycling may require additional energy. If these activities rely on carbon-intensive energy sources or involve inefficient logistics, the expected greenhouse gas reductions may be substantially reduced.

Life-cycle assessment (LCA) is therefore important for evaluating whether circular interventions generate genuine environmental improvements. Rather than comparing isolated production stages, LCA considers environmental impacts across the relevant product life cycle and provides a basis for evaluating alternative material and production pathways.

5.3. Water, pollution, and ecosystem-related benefits

Circular economy practices can also contribute to water conservation and pollution prevention. Industrial water recycling, closed-loop cooling systems, wastewater treatment and reuse, and improved process efficiency can reduce freshwater demand and wastewater discharge.

Cleaner production and improved material management can reduce air emissions, chemical losses, and industrial waste. Recovering materials from production residues can also reduce the environmental pressures associated with primary resource extraction. The relevance of circular economy practices to broader sustainability objectives is demonstrated by Schroeder et al. (2019), who identified potential connections between CE practices and several Sustainable Development Goals, particularly those related to clean water, clean energy, decent work, responsible consumption and production, and terrestrial ecosystems.

However, these relationships can involve both synergies and trade-offs, meaning that environmental and social outcomes should be evaluated together. For example, increased recycling may reduce material disposal but can also expose workers to hazardous substances when appropriate occupational health and safety measures are absent. Similarly, intensive collection and transportation activities can create additional emissions. Effective circular management should therefore integrate pollution prevention, occupational safety, resource conservation, and environmental protection.

5.4. Environmental trade-offs and rebound effects

Despite its environmental potential, circular economy implementation can generate unintended consequences. One important concern is the rebound effect, whereby improvements in resource efficiency reduce production costs or product prices and consequently stimulate additional consumption. Zink and Geyer (2017) highlighted that closing material loops does not necessarily guarantee reductions in primary production because recovered materials may supplement rather than displace virgin materials. This distinction is important because recycling rates alone cannot establish whether circular interventions produce net environmental benefits (Table 3).

Table 3. Environmental implications, potential benefits, and trade-offs of circular economy strategies.

Circular economy strategy	Potential environmental benefits	Environmental risks and trade-offs	Relevant performance indicators
Resource efficiency	Reduced virgin material use, energy consumption, and production waste	Efficiency improvements may stimulate additional production or consumption	Material intensity, energy intensity, resource productivity
Product reuse and repair	Extended product life, reduced demand for new products, lower material consumption	Transportation, maintenance, and additional component replacement requirements	Product lifetime, repair rate, reuse rate, avoided production
Remanufacturing	Recovery of product and component value, reduced demand for primary materials	Cleaning, disassembly, replacement, and processing energy requirements	Remanufacturing rate, material recovery, life-cycle emissions
Recycling	Reduced disposal, recovery of secondary materials, potential displacement of virgin resources	Material degradation, contamination, processing energy, and recovery losses	Recycling rate, secondary material content, recovery efficiency
Industrial symbiosis	Reduced waste disposal and improved utilization of industrial by-products	Additional transportation and processing requirements	By-product utilization, waste diversion, avoided virgin material consumption
Product-service systems	Improved asset utilization and potential reduction in product demand	Rebound effects and increased service-related transport or energy use	Asset utilization, product-to-service ratio, life-cycle impacts

Circular supply chains	Improved material traceability, recovery, and resource coordination	Complex logistics, additional transportation, and coordination requirements	Reverse logistics efficiency, recovered material flows, supply chain emissions

Source: Synthesized from Bocken et al. (2016), Korhonen et al. (2018), Zink and Geyer (2017), Haupt et al. (2017), and Schroeder et al. (2019).

Another concern involves the environmental burden associated with reverse logistics and recovery operations. Transporting products over long distances for repair, refurbishment, or recycling may offset some of the environmental benefits of material recovery. Similarly, recycling processes may require substantial energy and water or generate secondary waste streams.

Korhonen et al. (2018) emphasized that the circular economy is constrained by thermodynamic and physical realities. Materials cannot be recycled indefinitely without losses, and recycling processes require energy and other resources. Consequently, a fully closed material loop is not technically achievable for all materials and applications. The environmental performance of circular strategies should therefore be assessed through a life-cycle perspective that considers material substitution, energy consumption, transport, product quality, recovery efficiency, and the displacement of primary production. Organizations should avoid relying exclusively on indicators such as waste diverted from landfill or the percentage of recycled materials without examining the broader environmental consequences.

5.5. Environmental performance measurement and monitoring

Effective environmental evaluation requires indicators that measure actual improvements in resource productivity and environmental performance. Businesses can use material flow analysis, life-cycle assessment, environmental footprint indicators, and circularity metrics to evaluate circular economy implementation.

Potential indicators include virgin material consumption, recycled material content, material recovery rates, product lifetime, repair rates, waste generation, water consumption, energy intensity, greenhouse gas emissions, and the proportion of products recovered after use.

Haupt et al. (2017) emphasized the importance of selecting appropriate indicators for assessing circular economy performance. A high recycling rate, for example, does not necessarily demonstrate efficient resource use if material quality declines or the recovered material fails to replace primary resources. Businesses should therefore combine circularity indicators with conventional environmental performance measures. This enables organizations to distinguish improvements in material circulation from reductions in actual environmental pressures.

Environmental management systems can support this process by establishing baseline conditions, monitoring performance, identifying environmental risks, and evaluating progress against measurable objectives. Digital technologies can further strengthen monitoring through automated data collection, material tracking, and predictive analysis.

5.6. Future research directions

Although circular economy research has expanded considerably, several knowledge gaps remain relevant to sustainable business management. First, future studies should improve the measurement of circular economy implementation and environmental performance. Existing research frequently uses different definitions,

indicators, and methodological approaches, making cross-sector and cross-country comparisons difficult. More standardized measurement frameworks are needed to distinguish circular activities from actual reductions in environmental impacts.

Second, longitudinal research is necessary to understand the long-term economic and environmental consequences of circular business models. Many existing studies focus on conceptual frameworks, individual case studies, or short-term implementation experiences. Future research should examine how circular strategies influence corporate performance, resource productivity, and environmental outcomes over extended periods.

Third, additional research is needed on SMEs and businesses operating in developing economies. These organizations may experience distinct financial, technological, infrastructural, and institutional challenges. Research should investigate how collaborative platforms, shared infrastructure, public incentives, and appropriate business models can improve circular adoption under resource-constrained conditions.

Fourth, digital technologies require more rigorous evaluation. Although artificial intelligence, IoT, blockchain, and digital product information systems offer opportunities to improve traceability and resource management, their implementation can create additional energy consumption, electronic waste, cybersecurity risks, and data governance challenges. Research should assess their net contributions to circularity and environmental sustainability.

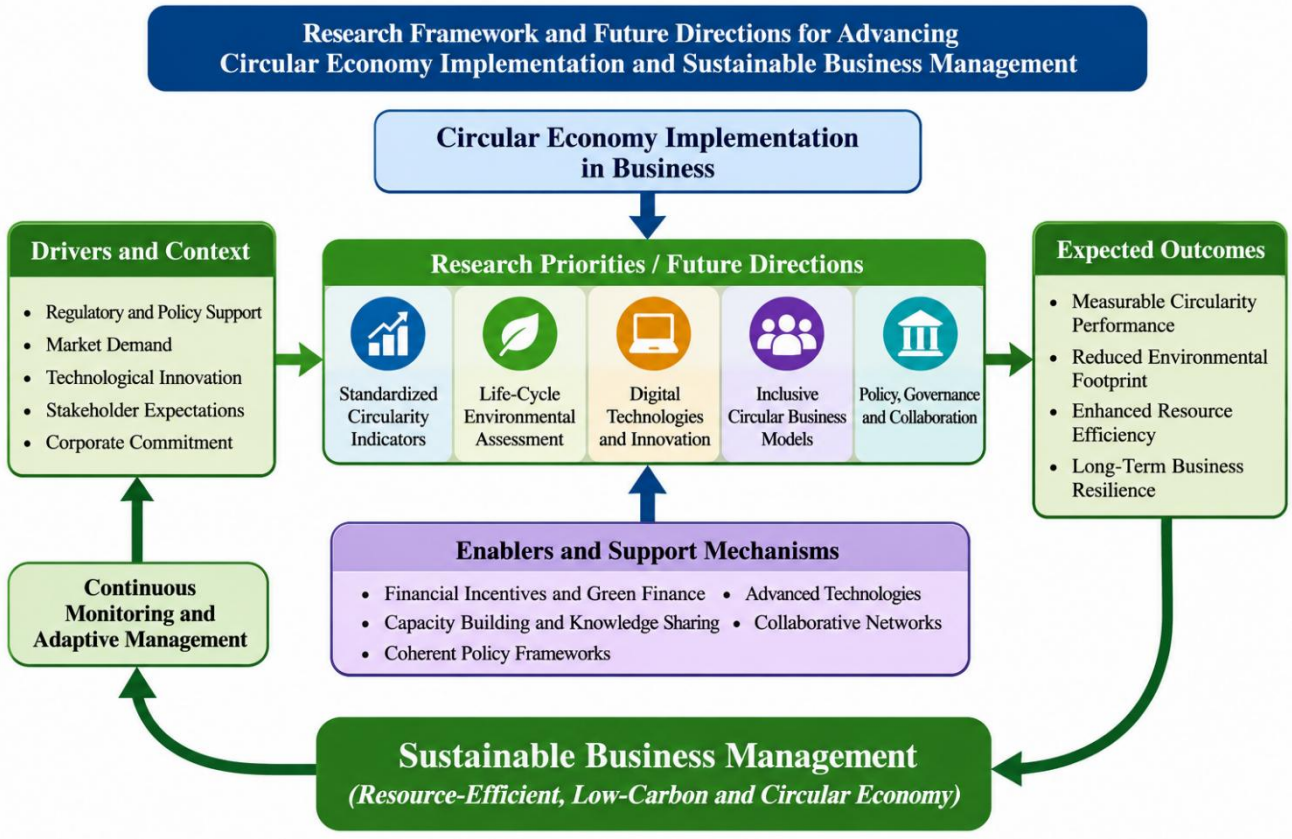


Figure 2. Research framework and future directions for advancing circular economy implementation and sustainable business management.

Fifth, future studies should investigate the relationship between circular economy practices and broader environmental and social sustainability objectives. This includes examining climate mitigation, biodiversity

protection, water conservation, occupational safety, social inclusion, and responsible consumption. Finally, greater attention should be given to the interaction between policy frameworks, corporate governance, financial mechanisms, and circular business model innovation.

Understanding these relationships can help policymakers and business leaders design interventions that support circular transformation while maintaining economic viability and environmental integrity. The proposed future research framework is presented in Figure 2. It identifies five interconnected priorities: standardized circularity assessment, life-cycle environmental evaluation, digital innovation, inclusive circular business models, and policy and governance integration.

Overall, environmental benefits should be considered an outcome to be demonstrated rather than an automatic consequence of circular economy adoption. Integrating life-cycle assessment, material flow analysis, environmental indicators, and long-term performance monitoring can help businesses identify effective strategies and avoid unintended environmental trade-offs.

6. Conclusions

The circular economy offers an important framework for transforming conventional business operations toward more resource-efficient, environmentally responsible, and sustainable management systems. This review demonstrates that circular economy implementation extends beyond recycling and waste management to include resource efficiency, circular product design, product life extension, reuse, remanufacturing, innovative business models, and sustainable supply chain management. The transition toward circular business practices is influenced by interconnected financial, technological, organizational, institutional, market, and supply chain factors. High investment requirements, inadequate infrastructure, limited technical expertise, regulatory uncertainty, weak consumer acceptance, and fragmented supply chains remain important barriers. Conversely, managerial commitment, technological innovation, supportive policies, green finance, employee engagement, digitalization, and stakeholder collaboration can facilitate successful implementation.

From an environmental perspective, circular economy strategies offer opportunities to reduce virgin resource consumption, minimize waste, improve material productivity, and potentially mitigate greenhouse gas emissions. Nevertheless, their effectiveness depends on life-cycle characteristics, recovery efficiency, energy sources, transportation requirements, material quality, and possible rebound effects. Consequently, circularity should be evaluated through comprehensive environmental performance assessment rather than relying exclusively on recycling or recovery rates.

The review highlights the importance of integrating circular economy principles into corporate strategy, operational management, product development, supply chain coordination, and environmental performance monitoring. Future research should prioritize standardized circularity indicators, longitudinal assessments, digital innovation, SME implementation, and the integration of economic, environmental, and social sustainability objectives. Ultimately, successful circular economy implementation requires coordinated organizational and institutional transformation supported by measurable environmental outcomes and viable business models.

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