

# Circular Economy Profitability in Pharmaceutical Drug Delivery Systems: A Sustainability Framework Integrating Green Leadership and Environmental Accounting

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## Abstract

The mounting pressure on the pharmaceutical industry to address issues such as resource consumption, hazardous waste generation, unsustainable packaging, and carbon emissions from drug delivery systems and healthcare operations is growing. Linear production models, centered on extraction, consumption, and disposal, are no longer sufficient to guarantee sustainable environmental outcomes and profitability in the long term. This study investigates how the principles of the circular economy can enhance the profitability and sustainability of pharmaceutical drug delivery systems by integrating green leadership and environmental accounting. The study is conceptual and secondary in nature, drawing on open-access academic literature, sustainability reports, and publications by institutions related to the circular economy, pharmaceutical sustainability, environmental management, and green organizational practices. The results show that implementing the circular economy reduces waste, optimizes resources, enables sustainable supply chain management, and supports efficient operation in pharmaceutical systems. The study also emphasizes that green leadership is an important factor in fostering green organizational culture and strategic environmental decision-making, and environmental accounting facilitates sustainability measurement, cost analysis, and profitability evaluation. The research offers an integrated sustainability framework based on the findings, which involves both circular economy practices and green leadership, environmental accounting, sustainability innovation, and stakeholder engagement, aiming to enhance environmental performance and sustainable profitability. The study finds that sustainable pharmaceutical transformation can create substantial economic, environmental, and strategic advantages, ensure regulatory compliance, and promote healthcare sustainability goals. The framework proposed in this work is a contribution to the literature on sustainability, as it provides a holistic model dedicated to drug delivery systems in the pharmaceutical sector.

## Keywords

Circular Economy; Pharmaceutical Sustainability; Green Leadership; Environmental Accounting; Drug Delivery Systems; Sustainable Profitability; Healthcare Waste Management

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## . Introduction

Pharmaceuticals are a key contributor to the healthcare systems worldwide and are responsible for creating new therapies and other advanced drug delivery methods that enhances the lives of patients and their quality of care. The sector also has significant environmental issues to deal with, such as high resource usage, high levels of hazardous waste, carbon emissions, and unsustainable packaging. As the world demands more and more pharmaceutical products, environmental pollution, waste management and natural resource depletion have become increasingly important issues. This has created a challenge for pharmaceutical companies who wish to

ensure that sustainability is embedded within their strategy and become profitable while also taking into account their responsibilities towards the environment and society (Geissdoerfer et al., 2017).

The concept of the circular economy has become a paradigm shift to sustainable industrial development in recent years. The circular economy is a shift from the conventional linear take-make-dispose economic model towards resource efficiency, reuse, recycling, remanufacturing, and waste minimization. The key goal of the circular economy is to maximize the use of products and minimize environmental and economic harm, thereby helping to extend their life cycles

(Kirchherr, Reike and Hekkert, 2017). In the pharmaceutical industry, circular economy principles can help achieve sustainable manufacturing, reverse logistics, eco-friendly packaging, efficient waste management, and optimized supply chain operations.

Drug delivery systems are one of the most critical elements of pharmaceutical operations as they require the use of a large amount of materials, packaging, transport and produce post-consumer waste. Traditional drug delivery systems frequently involve single-use plastics and materials that do not break down in the environment as well as manufacturing processes that consume a great deal of energy. These activities lead to the pollution of the environment and to higher operating costs. Thus, the potential for the circular economy approach towards pharmaceutical drug delivery systems is to decrease waste, optimise resource usage, and to gain better profits from sustainable operational strategies (Korhonen, Honkasalo and Seppälä, 2018).

With the rise of the importance of environmental sustainability, green leadership has become a crucial factor in organizations. Green leadership means that this is the practice of the manager to include environmental responsibility, sustainable innovation and ethical decision making within business practices. By fostering a culture of sustainability within the organizations, effective green leadership allows organizations to integrate sustainability objectives with organizational strategy and culture. In the pharmaceutical sector, green leadership can help to implement environmentally friendly technologies, circular production processes and sustainable approaches to supply chain (Zhu, Sarkis and Lai, 2012). Furthermore, leadership commitment to sustainability can help to boost employee engagement, company reputation and stakeholder trust.

Environmental accounting is another key element to sustainable business transformation. Environmental Accounting is the recognition, quantification and disclosure of environmental costs, environmental resources consumption, environmental releases and environmental sustainability effects. Typical accounting frameworks are not able to measure the actual environmental consequences of production, waste and resource depletion. Environmental accounting can deliver correct sustainability financial data to an organization which can help them make strategic decisions and to carry out a long term profitability analysis (Bebbington and Larrinaga, 2014). Environmental accounting can be used in the pharmaceutical sector to assess the economic value of recycling programs, waste minimisation, the use of alternative energy and efficient technologies, and the implementation of sustainable packaging solutions.

Pharmaceutical companies can benefit from a circular economy by incorporating green leadership and environmental accounting, which can bring about valuable competitive advantages. Circular economy strategies not only help to improve the environmental sustainability of a project but also the operational efficiency, cost reduction, compliance with regulations, and brand image. Govindan and Hasanagic (2018) report that companies that implement CE practices tend to achieve improved resource productivity, and long-term economic resilience. In the same way, environmental accounting methods help companies measure their sustainability performance and pinpoint areas for enhancing profitability while cutting down on ecological footprint.

Increasingly, healthcare systems around the world see the value of sustainability for medical and pharmaceutical activities. The World Health Organization (WHO, 2022) pointed out that waste and emissions in the healthcare sector play a significant role in environmental pollution and public health. The Pharmaceutical industry is increasingly being called on by governments, environmental agencies, investors and consumers to adopt sustainable business models. The European Commission Circular Economy Action Plan (CEAP) also supports and pushes industry towards environmentally sustainable production and consumption systems (European Commission, 2020).

Although there has been a growing academic and industrial interest in the applications of circular economy, few studies have focused on the circular economy profitability, green leadership and environmental accounting integration in the pharmaceutical drug delivery system. Previous studies have mostly examined the sustainable manufacturing, waste management in healthcare, or environmental reporting separately, without looking at how these are interlinked. The aim of the research is to realize this by developing a sustainability blueprint which is centered on the principles of circular economy, green leadership and environmental accounting that will enhance the profitability and sustainability in pharmaceutical drug delivery systems.

The importance of the research is that it can help both theoretically and practically in the management of pharmaceuticals for sustainability. The proposed framework can help pharmaceutical companies develop environmentally oriented strategies, which at the same time will increase operational efficiency and the economic results. Moreover, this study fills the gaps in the sustainability literature by combining managerial leadership, environmental accounting and circular

economy elements into a singular and common language, grounded on profitability.

The main goal of this research is to create a comprehensive sustainability framework of pharmaceutical drug delivery systems based on the principles of circular economy, green leadership and environmental accounting practices. The study also seeks to explore the impact of these interwoven factors on profitability, environmental impact and long-term sustainability of the organization.

The research with the following objectives:

1. To understand the role of Circular economy practices in Pharmaceutical Drug Delivery Systems.
2. To explore the impact of green leadership on sustainable pharmaceutical business.
3. To assess the significance of environmental accounting in terms of sustainability as well as profitability.
4. To suggest a combined framework for the pharmaceutical sector to improve the environmental and economic performance.

The study's focus leads to the following research questions:

1. What are benefits of the circular economy concept to the profitability in pharmaceutical drug delivery systems?
2. Green leadership is a vital contribution to sustainable pharmaceutical operation, what is its contribution role?
3. What does the environmental accounting contribute to decision making for sustainability?
4. What are the benefits of an integrated sustainability framework for long-term environmental and financial performance?

The research methodology employed in this study is conceptual and secondary research, which involves conducting secondary data analysis through literature reviews, sustainability reports and open journals that have been released, and the availability of literature that covers the topics of circular economy, environmental accounting, pharmaceutical sustainability and green leadership. The study is not experimental or clinical, but aims to create a strategic sustainability framework. The research thus plays part in the development of sustainable management and strategic decision making in pharmaceutical industries.

## **2. Literature Review**

### **2.1 Introduction**

Environmental problems have been rising with the growth of industrial production, which has driven the world towards more sustainable business models and resource efficient production systems. The circular economy is one of these emerging models that has attracted considerable interest from the academic and industrial communities due to its promise of waste reduction, better use of resources and long-term profitability. Pharmaceutical industries are increasingly concerned with sustainability issues because of the increased demand on health care, its complex supply chain, high energy consumption, and significant pharmaceutical waste generation. Researchers and practitioners have thus focused on the need to embed the principles of circular economy, green leadership strategies and environmental accounting systems into the pharmaceutical company's operations.

This literature review critically explores the current research on the areas of circular economy practices, pharmaceutical sustainability, green leadership, environmental accounting and profitability frameworks. The section also pinpoints significant gaps in the research and lays the groundwork for the proposed sustainability framework.

### **2.2 Circular Economy Concept and Principles**

Circular economy is a regenerative economic system, which aims to reduce the amount of waste, by minimizing its generation, and maximizing its use through reuse, recycling, remanufacture and sustainable production processes. The circular economy is based on a different concept from the linear economy, which is known as 'take-produce-dispose'. The circular economy aims to increase the lifespan of products, thereby minimizing environmental impact. (Geissdoerfer et al., 2017).

More than a century of definitions of the circular economy were analyzed by Kirchherr, Reike and Hekkert (2017) and they found that the concept embraces three ideas: environmental quality, economic prosperity and social equity. The study highlighted the essential elements of a circular economy system, including sustainable flows of resources, material recovery and closed-loop supply chains. In the same way, Korhonen, Honkasalo and Seppälä (2018) pointed out that circular economy models seek to provide ecological sustainability, industrial productivity and economic growth.

The Ellen MacArthur Foundation (2019) reinforced the conceptual of circular economy with the following three principles:

1. Elimination of waste and pollution
2. The exchange of products and materials.
3. Regeneration of nature systems

These concepts promote organizations to redesign products, optimise the manufacturing system and adopt sustainable practices during the operation of the system. Circular economy measures can be adopted in the pharmaceutical sector, such as recyclable packaging, reverse logistics, sustainable procurement, drug manufacturing with sustainable materials, and waste recovery.

Circular economy also enhances economic resilience and profitability. According to Hartley (2024), implementing a circular economy approach in a business model can lead to various cost savings, better supply chain efficiency, and better innovation capabilities. Implementing a circular economy is thus not only a matter of environmental aspects, but also a key business strategy to achieve long-term financial sustainability.

### **2.3 Circular Economy in Pharmaceutical Drug Delivery Systems**

Pharmaceutical drug delivery systems are complex: manufacturing processes, packaging material, transportation and post-consumer disposal systems. Commonly, pharmaceutical operations produce hazardous waste, plastic pollution, expired drugs, and waste of resources. Consequently, sustainability issues

in the pharmaceutical value chain have gained considerable traction in both academia and industry for research.

Nami (2025) highlighted the need for the application of circular economy in the reverse supply chain of drugs. The research confirmed that the implementation of reverse logistics systems (medicine collection systems, recycling systems and material recovery systems) has a significant impact on the efficiency of the use of resources and the reduction of operational waste. Moreover, it fosters an environment that promotes pharmaceutical firms to adopt sustainable supply chain and recovery systems.

In the context of sustainable healthcare systems, Sepetis (2025) noted that the systems are increasingly interested in adopting circular economy (CE) behaviors in order to enhance environmental performance and keep the same level of service. The findings of the research indicated that circular operation strategies in healthcare organizations are associated with improved waste management, reduced environmental impact and increased organizational sustainability.

According to World Health Organization (WHO, 2022), there has been a significant rise in the volume of healthcare waste generated as a result of increase in pharmaceutical consumptions and usage of medical products. Pharmaceutical packaging waste, disposable medical materials and chemical residues are important sources of environmental pollution. Thus, circular economy strategies have emerged as crucial to address the waste accumulation and promote sustainability in healthcare systems.

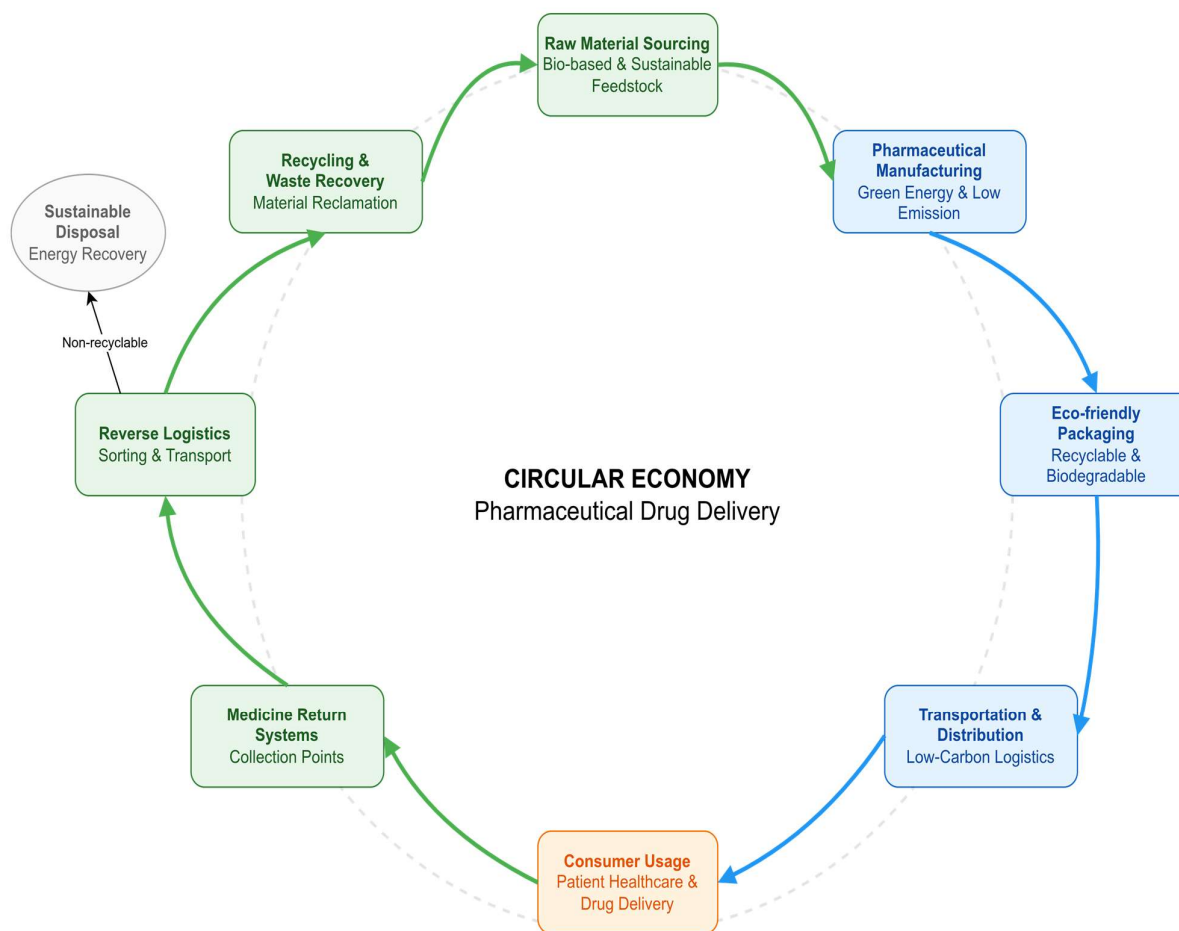


Figure 1: Circular Economy Flow in Pharmaceutical Drug Delivery Systems

## 2.4 Green Leadership and Sustainable Organizational Transformation

Green leadership is a leadership approach that advocates for environmental responsibility, sustainable innovation and ethical business practices. By embedding sustainability goals into the business processes, green leaders help shape the culture, behaviours and decisions of their organizations.

Zhu, Sarkis and Lai (2012) pointed out that leadership commitment to environmental innovation and green supply chain management is key in sustainable organizational transformation. They found that companies with higher environmental leadership are more likely to adopt sustainable technologies, decrease waste production, and enhance environmental performance.

Green leadership in a sustainability-focused organization fosters sustainable resource management, environmental friendly activities and sustainable long-term planning. Leaders also have a pivotal role to play in encouraging workers to take up sustainable work habits and join environmental activities. Good leadership is thus imperative for embedding principles

of an ecologic business model in pharmaceutical business.

Stakeholder theory was introduced by Freeman (1984) and has championed the need for organisations to focus on the needs of many stakeholders, such as customers, employees, governments, communities and environmental groups. Green leadership is similar to the stakeholder theory in that there is a balance between environmental and social responsibilities and economic profitability in sustainable decision making.

In the pharmaceutical industry, green leadership can have a positive impact on a number of sustainability-related activities, such as:

- Sustainable procurement policies
- Waste reduction initiatives
- Eco-friendly packaging systems
- Energy-efficient manufacturing
- A circular supply chain is developed.
- Environmental compliance strategies

Commitment to sustainability also improves the corporate image and investor confidence. Environmental, Social and Governance (ESG) is the basis on which modern investors measure the sustainability and long-term profitability of an organization.

### 2.5 Environmental Accounting and Sustainability Measurement

Environmental accounting is a process of discovering, quantifying, analyzing and reporting environmental costs and financial data regarding sustainability. Accounting systems are largely economic and tend to overlook the environmental aspects of external effects, including pollution, wastes, and resource depletion.

Bebbington and Larrinaga (2014) stated that environmental accounting is a very important factor for sustainable development as it allows the organisation to consider environmental costs in strategic business decisions. Environmental accounting systems assist companies understand the monetary results of their sustainability efforts, and discover opportunities to optimize resources.

Likewise, Burritt and Schaltegger (2010) pointed out that sustainability accounting helps to build transparency and sustainability in an organization, and for long-term value creation. The researchers have pointed out that the environmental accounting systems helps to enhance the sustainability reporting and helps to make environmentally responsible decisions.

Environmental accounting can be of assistance in pharmaceutical industries:

- Carbon emission tracking
- Cost analysis of waste management.
- Sustainable packaging evaluation
- Energy consumption monitoring
- Resource efficiency assessment
- Environmental compliance reporting

Portillo-Tarragona et al. (2025) also showed that eco-management accounting helps to foster eco-innovation and circular economy transitions. The research revealed that the use of an accounting system with a sustainability focus was more advantageous for attaining operational efficiency and environmental performance enhancements.

### 2.6 Circular Economy and Profitability Relationship

The debate over sustainability research is whether organizations are more profitable by being more

environmentally responsible or the other way around. Sustainability programs are typically viewed as a cost burden in traditional business models, but more recent research has shown that circular economy strategies can lead to better long-term financial outcomes.

According to Govindan and Hasanagic (2018), there are several factors that drive the adoption of circular economy, such as cost saving, regulatory compliance, innovation opportunities and competitive advantage. In their systematic review, they found that implementation of circular economy practices leads to better operational efficiency and less reliance on resources.

Additionally, Jabbour et al. (2019) highlighted the importance of the circular economy business models in achieving sustainable operations management through minimizing production waste, increasing resource productivity, and making supply chains more resilient. The study emphasized the financial stability and competitiveness of organizations that are environmentally sustainable over the long run.

### 2.7 Research Gap

While there are already many studies that have explored the concepts of circular economy practices, environmental accounting systems and green leadership separately, to date, few studies have combined these concepts in the context of pharmaceutical drug delivery systems. The literature mainly addresses general manufacturing industries or individual sustainable projects, and not sustainable frameworks in the pharmaceutical industry.

There are a number of key research gaps identified:

1. There are only limited studies specifically focused on the profitability of the pharmaceutical drug delivery system and its relationship to circular economy.
2. Most of the existing research focuses on the environmental accounting and the circular economy implementation separately.
3. There are very few studies that combine the concept of green leadership with sustainability profitability models.
4. The integration of sustainability, profit, leadership, and environmental accounting in the pharmaceutical field is underdeveloped in terms of conceptual research.
5. Only a small amount of research has been proposed on strategic sustainability models that can be adapted specifically for pharmaceutical supply chains and drug delivery systems.

To fill the above gaps, in this study, an integrated sustainability framework is proposed, which integrates the concepts of circular economy, green leadership and

environmental accounting systems for enhancing environmental performance and profitability in a pharmaceutical drug delivery system.

**Table 1:** Comparative Analysis of Previous Studies on Circular Economy and Pharmaceutical Sustainability

Author(s)	Focus Area	Key Findings	Research Limitation
Geissdoerfer et al. (2017)	Circular economy and sustainability	Circular economy improves resource efficiency and environmental sustainability	Limited focus on pharmaceutical industries
Kirchherr, Reike and Hekkert (2017)	Circular economy definitions	Identified major dimensions of circular economy systems	Lack of profitability-focused analysis
Govindan and Hasanagic (2018)	Circular economy implementation	Sustainability practices improve operational efficiency and competitiveness	General industrial focus only
Zhu, Sarkis and Lai (2012)	Green supply chain management	Green leadership supports environmental innovation and organizational improvement	Limited integration with accounting systems
Bebbington and Larrinaga (2014)	Environmental accounting	Environmental accounting strengthens sustainability decision-making	Does not address pharmaceutical applications
Portillo-Tarragona et al. (2025)	Environmental management accounting	Eco-innovation supports circular economy transition	Limited pharmaceutical sector analysis
Nami (2025)	Pharmaceutical reverse supply chains	Reverse logistics improves resource recovery and sustainability	Focused mainly on supply chain coordination
Sepetis (2025)	Sustainable healthcare systems	Circular behavior enhances healthcare sustainability	Limited discussion on profitability

### 3

#### . Research Methodology

The methodology used in this study is conceptual research and secondary research, which is aimed to examine the relationship between circular economy practices, green leadership, environmental accounting and profitability in pharmaceutical drug delivery systems. The study aims to create a sustainability framework that will combine these overlapping concepts in a comprehensive strategic model of the pharmaceutical industry. The research aims are directed towards the research field of Sustainability Management, organizational practices and theoretical integration, and not laboratory experiments or clinical testing, which makes a qualitative and conceptual research approach most suitable for achieving the research goals.

The sources of the study are mostly secondary sourced from open access academic journals, sustainability reporting, Institutional publications, healthcare reporting and international policy documents of circular economy and pharmaceutical sustainability. The secondary research method is appropriate for this research because the methods of collecting primary data are very expensive and time-consuming, and secondary

research will allow you to analyze existing theories, sustainability frameworks, industrial practices and an environmental accounting system. Furthermore, secondary sources enable an analysis of sustainability trends and a cross-industry and cross-research context analysis of the research results.

The methodological basis of the study is a comprehensive literature review that examines scholarly articles related to the implementation of the circular economy, sustainability of pharmaceuticals, environmental accounting, green leadership and sustainable profitability models. There is literature on the subject, which helps to understand how organisations incorporate sustainability into their decision making process at operational and strategic level. The literature also assists in determining gaps in the research and emerging sustainability practices, as well as some of the key factors affecting environmental and financial performance of pharmaceutical systems.

The research method is qualitative analytical research, which involves critically analyzing and appraising the existing theories and sustainability practices to be able to build an integrated framework. Qualitative research is suitable because the study aims at conceptual

understanding of the relationships among the variables of sustainability without statistical hypothesis testing. Thus the research is based on interpretative analysis, theoretical integration and conceptual model development. This allows a comprehensive understanding of the interaction between circular economy principles, leadership strategies and environmental accounting systems and explains their impact on profitability and long-term organizational sustainability.

The data used in the study were obtained from several reliable and open sources that would ensure the credibility and validity of the study. Peer-reviewed journals such as MDPI, Springer Open, Elsevier Open Access and institutional publications from the World Health Organization (WHO), European Commission, Ellen MacArthur Foundation are among the primary sources. These sources include up to date information relating to sustainable healthcare systems, environmental regulations, accounting frameworks and strategies for circular economy in the pharmaceutical sector.

Literature was chosen based on its relevance to the topic of the research, quality of the publication, content about sustainability, and accessibility. The studies published in the time frame 2017-2026 were chosen as priorities since there has been significant research development in the field of sustainability and circular economy in this time frame. Some basic theoretical studies were also included, however, to develop a conceptual framework and theoretical support to the proposed framework. The chosen literature covers all the four areas of circular economy ideas, pharmaceutical sustainability practices, environmental accounting systems, green leadership theories, and sustainability outcomes related to profitability.

The analytical process of the research was themed on the analysis of literature and synthesizing concepts. Selected variables were analysed using thematic analysis, to identify themes and relationships that were found across them. Waste reduction, reverse logistics, environmental responsibility, sustainable leadership, resource efficiency, profitability enhancement, eco-innovation and environmental cost management are key themes derived from the literature. These themes were explored systematically to gain insight into their role in the pharmaceutical drug delivery systems.

The results of the various studies were then conceptualized into an integrated sustainability framework through conceptual synthesis. The process consisted of identifying dimensions of sustainability across the models that were available, finding common dimensions of sustainability, and investigating how

different organizational practices contribute to environmental and economic performance. The synthesis approach enabled the study to integrate various theoretical views in an integrated conceptual framework that could then respond to the pharmaceutical sustainability issues holistically.

In addition, sustainability oriented analytical indicators are taken into account to assess the effectiveness of the implementation of circular economy in pharmaceutical systems. The environmental indicators taken into account in the study are the waste reduction efficiency, the use of resources, consumption of energy, capacity to recycle, reduction in carbon emissions and sustainable packaging practices. Operational Cost reduction, Profitability improvement, Resource productivity, Regulatory compliance efficiency, and Long Term financial sustainability are economic indicators. The indicators of leadership involve stakeholders involvement, innovation support, organizational environmental culture and commitment to sustainability.

The accounting of the environment is an important methodological aspect of this study as it offers measurable means of assessing sustainability performance and profitability outcomes. The research focuses on the contribution of environmental accounting systems to decision-making in organizations, as the costs of environmental impacts are identified, sustainability reports are prepared and environmental performance is evaluated. The incorporation of environmental accounting in the proposed framework, allows the study to relate sustainability efforts with financial evaluation processes.

In addition, the study uses stakeholder theory as a theoretical approach that supports the analysis of organizational behavior for sustainability. Stakeholder theory is a theory that businesses must consider the needs of stakeholders, including shareholders, customers, employees, regulators, communities and environmental groups. The enlightenment of this theoretical perspective underlies the fact that pharmaceutical companies need to operate in a sustainable way in order to generate value for investors, society and the environment. Therefore, it is crucial that sustainability practices are embedded in the organization and focus on stakeholder needs for long-term legitimacy and profitability.

Reliability and validity were ensured by relying on credible academic sources and following a consistent thematic analysis procedures. To ensure the quality of the findings, research has been avoided from unreliable and non-academic online sources. Analytical consistency was further achieved and the potential for bias minimized through cross-comparison of several

studies. In addition, the current sustainability literature used allows for the proposed framework to be reflective of current sustainability challenges and sustainability practices in industry.

Although it has many merits, the study has a number of methodological drawbacks. As the research is conceptual and secondary, it is not based on primary data collection from pharmaceutical companies and/or healthcare institutions. Therefore, the results are theoretical rather than from actual industry experience, or tested statistically. Moreover, there are geographical, regulatory and organizational differences between pharmaceutical companies when it comes to sustainability. Thus, the proposed framework can be further validated using empirical approach in future studies.

One of the other restrictions is the quick pace of change of sustainability regulations and environmental technologies. The concept of circular economy and environmental accounting standards are ongoing in the world, and future policy changes might impact the use of some of the sustainability strategies presented in this paper. The conceptual framework presented in this research however is still relevant as it is based on general sustainability principles which can be used in a variety of contexts in the pharmaceutical field.

Ethical issues were also taken care of in the process of research. This study does not include any human subjects or confidential organizational information as it is based on only second-hand data. Harvard referencing was used to ensure proper referencing of all materials used and to prevent academic plagiarism. The study also ensured that it was objective, subjective and evidence-based and uphold academic research standards.

#### 4. Proposed Sustainability Framework for Circular Economy Profitability in Pharmaceutical Drug Delivery Systems

The proposed sustainability framework is based on the principles of the circular economy, green leadership and

environmental accounting, which are designed to enhance sustainability and profitability in pharmaceutical drug delivery systems. The framework is based on the concepts of waste reduction, resource efficiency, sustainable manufacturing and increased long term operational performance.

Recycling, Reusable packaging, reverse logistics, waste recovery are all circular economy practices which help pharmaceutical organizations minimize the impact on the environment and reduce their costs. Resource use and environmental impact is further enhanced with sustainable manufacturing processes and eco-friendly packaging systems (Geissdoerfer et al., 2017).

Green leadership as the strategic pillar of the framework promotes decision making in favour of sustainability, environmental responsibility and innovation of organizations. Green operational practices and employee involvement in green measures are supported by effective leadership (Zhu, Sarkis and Lai, 2012).

Another key part of environmental accounting relates to measuring environmental costs, monitoring sustainability performance and assessing the financial value of sustainability programs, as this helps organizations to understand environmental costs and make decisions on sustainability programs. The environmental accounting systems increase transparency and assist in strategic planning in the context of sustainability (Bebbington and Larrinaga, 2014).

The framework also includes stakeholder engagement and sustainability innovation to further reinforce environmental accountability and competitiveness. By combining all these interdependent elements, pharmaceutical companies can optimize their operations, minimize waste, ensure regulatory compliance, and boost profitability.

The proposed framework offers a holistic solution for sustainable pharmaceutical operations, considering both environmental responsibility and economic growth.

**Table 2:** Components of the Proposed Sustainability Framework

Framework Component	Role in Pharmaceutical Sustainability	Expected Outcome
Circular Economy Practices	Reduce waste, improve recycling and resource utilization	Environmental sustainability and cost reduction
Green Leadership	Promote sustainability-oriented organizational culture and decision-making	Improved implementation of environmental strategies
Environmental Accounting	Measure environmental costs and sustainability performance	Better financial and sustainability evaluation
Reverse Logistics	Recover expired medicines and recyclable materials	Reduced pharmaceutical waste and improved resource recovery
Sustainability Innovation	Develop eco-friendly technologies and packaging systems	Improved operational efficiency and competitiveness

Stakeholder Engagement	Support transparency and regulatory compliance	Stronger organizational reputation and ESG performance
Sustainable Supply Chain Management	Optimize transportation, packaging, and procurement systems	Increased profitability and reduced environmental impact

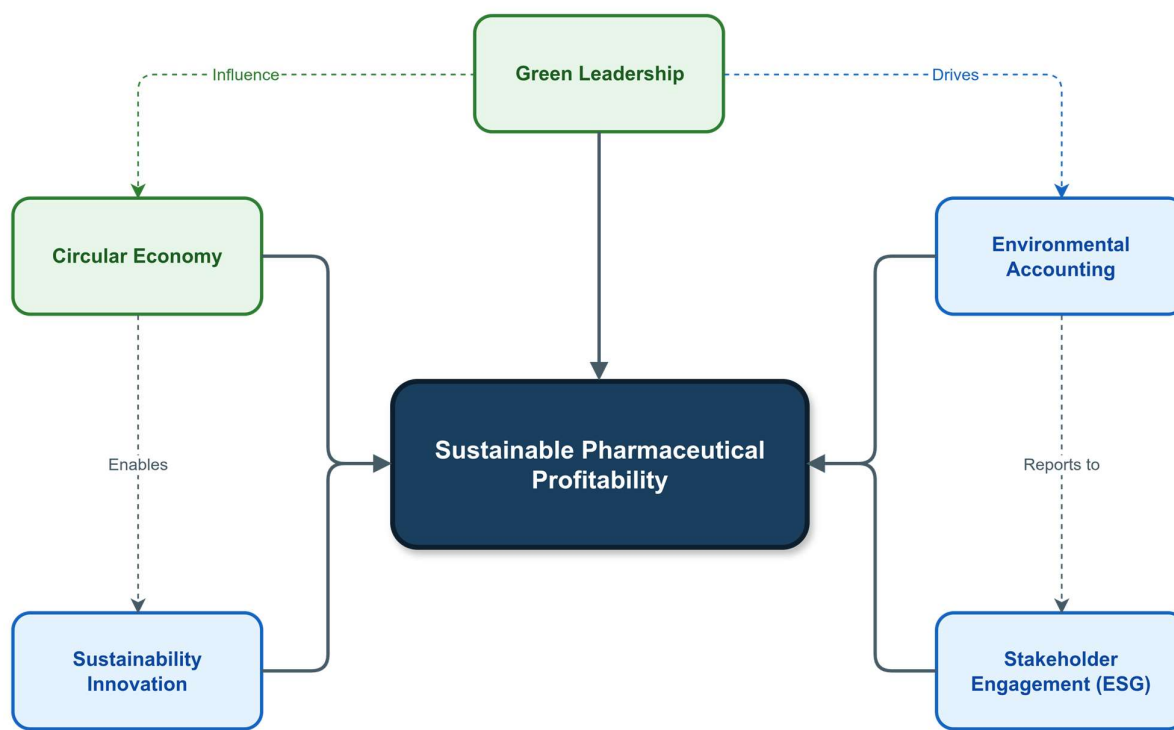


Figure 2: Integrated Sustainability Framework for Circular Economy Profitability in Pharmaceutical Drug Delivery Systems

### 5. Discussion

The results of this research show that implementing principles of circular economy, green leadership and environmental accounting can have a meaningful positive impact on the sustainability and profitability of pharmaceutical drug delivery systems. Pharmaceutical companies can minimize the environmental impact and optimize their operations through circular economy initiatives like recycling, waste reduction, sustainable packaging, and reverse logistics. These practices also reduce production and waste management cost which will ultimately benefit the profitability of the business for a longer term basis (Govindan and Hasanagic, 2018).

The study also shows the importance of green leadership in fostering a culture of sustainability and environmental decision making within organizations. Human resource management leaders who are involved in sustainable innovation and environmental responsibility can enhance employee involvement and deepen the circular economy approach. Good leadership also improves organisational reputation and stakeholders' trust,

especially in sectors where there is growing demand for ESG and sustainability.

Another critical factor that was identified in support of sustainable pharmaceutical management was environmental accounting. Environmental accounting systems enable organisations to assess sustainability performance better by measuring environmental costs, waste generation and resource consumption. The systems increase transparency, enable regulatory compliance, and help identify potential savings in operational costs from sustainability initiatives (Bebbington and Larrinaga, 2014).

Also, several issues were discussed that hinder the application of the CE in the pharmaceutical industries. Sustainability transformation can be slow due to various obstacles, including high implementation costs, technological constraints, complex regulations, and change resistance of the organizations involved. But, with long-term investment planning, sustainability innovation, training employees and effective environmental policies, organizations can overcome these hurdles.

In general, the study showed that the implementation of pharmaceutical companies' CE strategies, with the help of green leadership and environmental accounting, was more likely to lead to environmental sustainability, operational efficiency, and economic competitiveness in the long term. Hence, sustainable transformation is an

important strategic goal for the modern pharmaceutical companies.

**Table 3:** Challenges and Strategic Solutions for Circular Economy Implementation in Pharmaceutical Industries

Major Challenge	Impact on Pharmaceutical Industry	Strategic Solution
High implementation costs	Delays adoption of sustainable technologies	Long-term sustainability investment planning
Regulatory complexity	Restricts packaging reuse and recycling systems	Development of sustainability-focused regulations
Organizational resistance to change	Slows sustainability transformation	Employee training and green leadership initiatives
Limited recycling infrastructure	Reduces effectiveness of reverse logistics systems	Public-private sustainability partnerships
Lack of environmental accounting systems	Weak sustainability measurement and reporting	Adoption of integrated environmental accounting
Technological limitations	Restricts eco-friendly production innovation	Investment in sustainability research and development
Supply chain complexity	Increases waste and operational inefficiency	Sustainable supply chain optimization strategies
Limited sustainability awareness	Weak stakeholder participation	Sustainability education and ESG communication programs

**6**

**. Conclusion and Recommendations**

The study focused on the potential of circular economy principles, green leadership and environmental accounting in enhancing the sustainability and profitability of pharmaceutical drug delivery systems. Results show that the practices of the circular economy can reduce waste, recycle, use sustainable packaging and implement reverse logistics to decrease the environmental impact and increase operational efficiency. These practices also help to ensure long-term viability by reducing costs and optimizing resource use.

The research also revealed green leadership as an important enabler of the transformation towards sustainability in pharmaceutical companies. Good leadership fosters environmental responsibility, sustainable innovation and strategic application of CE practices. A need for the environmental accounting was also identified in measuring environmental costs, monitoring environmental sustainability and informing decision making.

The proffered sustainability framework brings together the elements of circular economy practices, green leadership, environment accounting, sustainability innovation, and stakeholder engagement as a pharmaceutical sustainability model. The framework offers strategic direction for pharmaceutical companies

aiming to achieve environmental sustainability and economic competitiveness at the same time.

While the advantages are considerable, there are various obstacles, including the implementation expenses, technological constraints, and regulatory intricacies, which can influence the uptake of sustainability. Hence, pharmaceutical companies need to focus on sustainable supply chain management, sustainable accounting systems, employee education, and innovation in sustainability. Government and policy makers also need to promote the uptake of circular economy through effective environmental policies and sustainability support measures.

The study concludes that overall, the pharmaceutical industries have to undertake sustainable transformation in order to secure their future in the long run. Circular Economy is more likely to be achieved in combination with good leadership and environmental accountability and improve long-term environmental performance, operational efficiency and profitability of organizations.

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