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# IMPACT OF AI ON SUSTAINABLE CIRCULAR ECONOMY: HARNESSING ARTIFICIAL INTELLIGENCE

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## ABSTRACT
*This study explores how Artificial Intelligence (AI) supports the transition to a sustainable circular economy. A circular economy focuses on reducing waste, reusing resources, and promoting long-term environmental health. The research reviews ten academic papers to understand how AI technologies—like machine learning, smart sensors, and predictive tools— are being used in industries to minimize waste, improve resource use, and enhance supply chain efficiency.*

*Findings show that AI is already being applied successfully in areas like urban waste management, electric vehicle production, and manufacturing. For example, intelligent sorting systems and real-time data analysis help in recycling and reducing environmental impact. The study also highlights how collaborations between governments and industries, such as in Ireland, have led to positive outcomes in sustainability through AI-based solutions.*

*Despite its benefits, the review points out several challenges. These include high costs, data privacy issues, and uneven readiness for adopting AI technologies. Moreover, most current research focuses more on theory than on practical, real-world applications. There is also a lack of studies that connect AI with social, economic, and policy factors in a meaningful way.*

*The paper concludes that AI has great potential to drive sustainability and support circular economy goals. However, for it to be fully effective, more practical research, better policies, and strong cross-sector partnerships are needed. With the right efforts, AI can become a key force in building a greener, more resilient global economy.*

**KEYWORDS:** *Artificial Intelligence (AI), Circular Economy, Sustainable Development, Waste Reduction, Urban Waste Management, Environmental Sustainability.*

## INTRODUCTION

Artificial Intelligence (AI) is rapidly transforming industries and societies by introducing innovative solutions to complex challenges. One of the most critical areas where AI is making a significant impact is the sustainable circular economy, particularly in waste management and minimization. The concept of a circular economy aims to eliminate waste and promote the continual use of resources through principles like reuse, recycling, refurbishment, and sustainable production. In this context, AI serves as a catalyst, driving efficiency and innovation in waste management practices.

The traditional linear economy, characterized by the take-make-dispose model, has led to significant environmental degradation and resource depletion. As global awareness of sustainability increases, there is a shift toward circularity, where waste is seen not as an endpoint but as a resource. However, managing this transition requires advanced technologies that can handle complex, dynamic systems efficiently—this is where AI becomes indispensable.

AI technologies such as machine learning, computer vision, predictive analytics, and automation offer unprecedented opportunities to optimize resource management. For instance, AI-powered waste sorting systems use image recognition and robotic arms to segregate waste with high accuracy, significantly reducing contamination and improving recycling rates. Predictive maintenance driven by AI can monitor the condition of machinery in waste processing plants, minimizing downtime and reducing waste generated from equipment failure.

Moreover, AI facilitates data-driven decision-making, enabling municipalities and industries to develop more efficient waste management strategies. By analyzing vast amounts of data from waste generation patterns, AI algorithms can predict waste surges, allowing for proactive measures in collection and processing. This level of precision reduces both operational costs and environmental impact.

In addition, AI aids in tracking and monitoring waste throughout its lifecycle. Smart sensors and IoT (Internet of Things) devices integrated with AI can detect inefficiencies in waste management processes, such as overflow in bins or irregular collection schedules. This real- time monitoring supports timely interventions, ensuring that waste is collected and processed efficiently.

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Beyond operational improvements, AI also contributes to strategic planning in the circular economy. Advanced simulations and optimization models can forecast the long-term effects of various waste management policies, helping policymakers make informed decisions. As industries increasingly adopt sustainable practices, AI-driven solutions are becoming vital for achieving zero-waste goals and minimizing the ecological footprint.

Furthermore, AI promotes innovation in designing products with end-of-life considerations in mind. Through generative design and lifecycle analysis, AI helps manufacturers create products that are easier to recycle, disassemble, or repurpose. This integration of AI into the design phase aligns production practices with circular economy principles from the outset.

**In summary**, AI's transformative potential in sustainable circular economy practices is evident across various applications, from enhancing waste sorting and recycling to enabling proactive decision-making and strategic planning. By embedding AI into waste management systems, industries and municipalities can significantly reduce waste generation, improve recycling rates, and support a more sustainable and resilient economy.

## OBJECTIVES OF THE STUDY

The primary aim of this research is to explore the intersection of Artificial Intelligence (AI) and sustainable circular economy practices, with a particular focus on waste management and minimization. To achieve this, the study sets forth the following specific objectives:

1. **Assess AI's Role**

To evaluate how AI contributes to the efficiency and effectiveness of waste management within a circular economy framework.

- This objective seeks to understand the transformative potential of AI in optimizing waste management practices.
- It aims to identify how AI can streamline waste segregation, processing, and recycling to reduce landfill dependency.

2. **Identify AI Applications**

To identify specific AI applications that facilitate waste minimization and promote sustainable practices.

- This objective involves mapping out the various AI technologies utilized in waste management, including machine learning, computer vision, robotics, and data analytics.
- The research will focus on categorizing AI applications based on their role in waste reduction, such as smart waste sorting systems, predictive maintenance of waste processing equipment, and intelligent supply chain management to reduce waste at the source.

3. **Analyze Economic and Environmental Impacts**

To analyze the economic and environmental outcomes resulting from integrating AI into waste management strategies.

- This objective aims to quantify the economic benefits of AI, such as cost savings from improved efficiency, reduced waste disposal expenses, and enhanced recycling revenue.
- It will also examine the environmental benefits, including reduced carbon emissions, conservation of natural resources, and decreased landfill dependency.

4. **Develop Strategic Recommendations**

To propose actionable strategies for integrating AI in waste management to support a sustainable circular economy.

- Based on the insights gathered, the study will develop strategic frameworks for industries and municipalities to adopt AI-driven waste management practices.
- The recommendations will address potential challenges, including data privacy

## NEED FOR THE STUDY

The escalating global waste crisis necessitates innovative solutions to manage waste sustainably. Traditional waste management methods often fall short in addressing the complexities of modern waste streams. AI offers promising avenues to revolutionize these processes by enabling:

- **Enhanced Decision-Making**: AI algorithms can process vast datasets to inform strategic decisions in waste collection, sorting, and recycling.
- **Operational Efficiency**: Automation and predictive analytics can streamline operations, reducing costs and resource consumption.
- **Environmental Sustainability**: Optimized processes lead to lower greenhouse gas emissions and reduced reliance on landfills.

## RESEARCH GAP

While existing literature acknowledges AI's potential in waste management, several gaps remain:

- **Comprehensive Impact Assessments**: Limited studies have quantitatively assessed the combined economic and environmental impacts of AI-driven waste management strategies.
- **Scalability and Adaptability**: There is a need for research on the scalability of AI solutions across different regions and waste types, considering local socio-economic factors.

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- **Integration Challenges**: Understanding the barriers to integrating AI with existing waste management infrastructures requires further exploration.

## RESEARCH METHODOLOGY

To address these gaps, the study will employ the following methodology:

1. **Literature Review**: Conduct a comprehensive review of existing research on AI applications in waste management and circular economy models.
2. **Data Collection**: Gather data from municipalities and industries that have implemented AI-driven waste management systems.
3. **Case Studies**: Develop detailed case studies to analyze the implementation processes, challenges faced, and outcomes achieved.
4. **Economic and Environmental Analysis**: Utilize AI-based simulation models to evaluate the economic efficiencies and environmental benefits of AI integration in waste management.
5. **Stakeholder Interviews**: Conduct interviews with key stakeholders to gain insights into practical challenges and perceptions regarding AI adoption.

**Variable of interest: waste minimization**

The study focuses on waste minimization as the key variable, examining how AI applications can reduce waste generation at the source and enhance recycling and reuse processes. This includes exploring AI's role in:

- **Predictive Maintenance**: Preventing equipment failures that lead to waste.
- **Demand Forecasting**: Aligning production with consumption patterns to minimize surplus.
- **Smart Sorting Systems**: Improving the accuracy of material segregation for recycling.

## LITERATURE REVIEW

**1. "Shaping the Future of Sustainable Energy through AI-Enabled Circular Economy Policies" by Mir Sayed Shah Danish and Tomonobu Senjyu (2023)**

This study proposes an AI-driven policy framework that aligns with circular economy principles to address transformations in energy policy development. It identifies key trends and evaluates AI's potential in overcoming challenges within the energy sector. The framework offers a roadmap for stakeholders to harness AI for a sustainable energy future, emphasizing the need for policies that integrate AI with circular economy models to achieve decarbonization and sustainability goals.

**2. "A Conceptual Model of Artificial Intelligence Effects on Circular Economy Actions" by Ilaria Tutore, Adele Parmentola, Michele Costagliola di Fiore, and Francesco Calza (Year Not Specified)**

This paper develops a conceptual model illustrating how AI influences circular economy actions. It explores the mechanisms through which AI can enhance resource efficiency, waste reduction, and sustainable practices. The model serves as a foundation for understanding the interplay between AI technologies and circular economy initiatives, providing insights into how AI can drive the transition towards more sustainable industrial operations.

**3. "AI-Driven Circular Economy of Enhancing Sustainability and Efficiency in Industrial Operations" by Bankole I. Oladapo, Mathew A. Olawumi, and Francis T. Omigbodun (2024)**

This research investigates the integration of circular economy principles into industrial sectors, focusing on refining, clean energy, and electric vehicles. Utilizing a mixed-methods approach, including qualitative case studies and quantitative modeling, the study quantifies the impact of circular practices on resource efficiency and environmental sustainability.

Findings indicate significant reductions in waste production and improvements in recycling efficiency, highlighting AI's role in optimizing industrial processes and promoting sustainable growth.

**4. "Artificial Intelligence and the Circular Economy: How AI Advances Waste Reduction" by Ahmad Sikander (Year Not Specified)**

This article examines the role of AI in advancing waste reduction within the circular economy framework. It discusses various AI applications that contribute to efficient waste management, such as predictive analytics for waste generation, smart sorting systems, and optimization of recycling processes. The study emphasizes AI's potential to transform waste management practices, leading to significant environmental benefits and resource conservation.

**5. "Towards a Circular Economy: Integration of AI in Waste Management for Sustainable Urban Growth" by Faurani Santi Singagerda, Deshinta Arrova Dewi, Sherli Trisnawati, Linda Septarina, and M. Rama Dhika (Year Not Specified)**

This paper explores the integration of AI in urban waste management to promote sustainable urban growth. It highlights how AI technologies can enhance waste collection, sorting, and recycling processes in urban settings. The study provides case studies demonstrating successful AI implementations in waste management, showcasing improvements in operational efficiency and reductions in environmental impact.

**6. "The Role of AI in Circular Economy Supply Chains: A Comparative Analysis of Industry Practices" by Vishakha Ashish Mankar, Athar Javed Ali, Reema Kamlani, Yogita Sure, Shailesh Kediya, and Amit Gudadhe (Year Not**

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**Specified)**
This research conducts a comparative analysis of how various industries employ AI within their circular economy supply chains. It identifies best practices, challenges, and the overall impact of AI on supply chain sustainability. The study offers insights into how AI can be leveraged to create more resilient and efficient supply chains that align with circular economy principles.

**7. "The Role of Artificial Intelligence within Circular Economy Activities—A View from Ireland" by Muhammad Salman Pathan, Edana Richardson, and Edgar Galvan (2023)**
Focusing on Ireland, this paper discusses the intersection of AI and circular economy policies. It reviews initiatives by the Irish government to adopt circularity and explores the role of AI in these efforts. The study presents practical examples of AI applications in circular economy activities, arguing for the significant potential of digitalization in facilitating the transition towards sustainable practices.

**8. "Leveraging Artificial Intelligence for Circular Economy: Transforming Resource Management, Supply Chains, and Manufacturing Practices" by Iryna Bashynska and Olha Prokopenko (2024)**
This article examines how AI can transform resource management, supply chains, and manufacturing practices within the circular economy framework. It discusses AI-driven strategies for optimizing resource utilization, minimizing waste, and enhancing the sustainability of manufacturing processes. The study provides a comprehensive overview of AI's transformative potential in promoting circular economy objectives across various industrial sectors.

**9. "Role of Artificial Intelligence in Circular Economy: A Step Towards Green World" by Sakshi Yadav (Year Not Specified)**
This paper highlights AI's role as a pivotal tool in advancing circular economy initiatives aimed at environmental sustainability. It discusses various AI applications that contribute to waste reduction, resource efficiency, and sustainable production. The study emphasizes the importance of integrating AI technologies to achieve a greener and more sustainable world.

**10. "Green AI for Sustainability: Leveraging Machine Learning to Drive a Circular Economy" by Ahmed Hussein Ali (Year Not Specified)**
This research focuses on the concept of 'Green AI' and how machine learning can drive circular economy practices. It explores the environmental benefits of applying AI to optimize processes, reduce waste, and promote sustainable resource management. The study underscores the synergy between AI advancements and sustainability goals, advocating for the adoption of AI to foster a circular economy.

Collectively, these studies underscore the transformative potential of AI in advancing circular economy practices across various sectors. They highlight AI's capacity to optimize resource management, enhance waste reduction, and promote sustainable industrial operations, thereby contributing significantly to environmental sustainability and economic efficiency.

**11. "Artificial Intelligence in Circular Economies: A Pathway to Sustainable Resource Management" by Jatin Pal Singh (2023)**
This paper explores the role of AI in enhancing circular economy practices, focusing on sustainable resource management. It discusses AI-enabled resource tracking, predictive analytics for resource consumption, and optimization of resource lifecycles. The study also addresses potential drawbacks, such as biases in AI algorithms, and provides policy recommendations for integrating AI into sustainability efforts.

**12. "Generative AI Usage and Sustainable Supply Chain Performance: A Study on the Fashion Industry" by [Authors Not Specified] (2024)**
This research examines the application of generative AI in enhancing sustainable supply chain performance within the fashion industry. It analyzes how AI can optimize design processes, reduce waste, and improve resource efficiency. The study provides insights into the potential of AI to drive sustainability in supply chains.

**13. "AI-Driven Digital Circular Economy with Material and Energy Efficiency" by [Authors Not Specified] (2025)**
This study investigates the integration of AI with digital technologies to promote a circular economy focusing on material and energy efficiency. It explores how AI can facilitate carbon trading, predict biomass waste heating values, and optimize resource utilization. The research highlights AI's role in achieving sustainability goals.

**14. "Revolutionizing Urban Solid Waste Management with AI and IoT: A Review" by [Authors Not Specified] (2025)**
This review discusses the transformative potential of AI and Internet of Things (IoT) technologies in urban solid waste management. It emphasizes how these technologies can enhance waste collection, sorting, and recycling processes, contributing to the development of a circular economy and reduction of environmental impacts.

**15. "Artificial Intelligence and Circular Supply Chains: Framework for Applications and Deployment" by Rahul Meena, Saumyaranjan Sahoo, Ashish Malik, Satish Kumar, and Mai Nguyen (2025)**
This research presents a framework for applying AI in circular supply chains, focusing on recycling, reuse, and reduction strategies. It discusses how AI can automate manufacturing and supply chain processes, contributing to sustainable and ethical circular supply chains.

**16. "Employing Artificial Intelligence and Enhancing Resource Efficiency to Promote Circular Economy in Industries" by [Authors Not Specified] (2023)**
This paper explores the use of AI to improve resource efficiency and promote circular economy practices in industrial settings. It provides practical recommendations for implementing sustainable AI, investing in green technologies, and developing a skilled workforce to support these initiatives.

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**17. "Evaluating Artificial Intelligence Models for Resource Allocation in Circular Economy Digital Marketplaces" by [Authors Not Specified] (2024)**

This study assesses various AI algorithms for optimizing resource allocation, demand-supply matching, and dynamic pricing within circular economy digital marketplaces. It evaluates models like ARIMA, LSTM, random forest, gradient boosting regressor, and neural networks for their effectiveness in predicting waste generation and managing resource flows.

## ANALYSIS & INTERPRETATION OF DATA

### A. Reliability Analysis

**Reliability**

[DataSet1]

**Scale: ALL VARIABLES**

**Case Processing Summary**

| | | N | % |
|---|---|---|---|
| Cases | Valid | 677 | 100.0 |
| | Excluded[a] | 0 | .0 |
| | Total | 677 | 100.0 |

a. Listwise deletion based on all variables in the procedure.

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| .753 | 4 |

**Reliability analysis interpretation**

The provided SPSS output presents the reliability analysis for the variables used in a study exploring the integration of Artificial Intelligence (AI) within Circular Economy practices. This analysis is crucial to validate the internal consistency of the scale or questionnaire used in the research.

The Case Processing Summary section indicates that all 677 responses were valid and included in the analysis, with 0 cases excluded. This means that the dataset was complete, with no missing values among the selected items, allowing for a robust and reliable interpretation of the reliability statistics.

The Reliability Statistics table shows a Cronbach's Alpha value of 0.753 for the four items included in the scale. Cronbach's Alpha is a widely accepted measure of internal consistency or reliability of a set of scale or test items. It ranges between 0 and 1, with higher values indicating greater reliability. The commonly accepted thresholds for interpreting Cronbach's Alpha are:

- 0.9 = Excellent
- 0.8 – 0.9 = Good
- 0.7 – 0.8 = Acceptable
- 0.6 – 0.7 = Questionable
- < 0.6 = Poor

In this context, a value of 0.753 falls within the "acceptable" range, suggesting that the four items used in the questionnaire are reasonably consistent in measuring a common underlying construct—likely the effectiveness or perceptions of AI integration in Circular Economy operations. This consistency ensures that the responses are not random and that the items reliably capture meaningful data relevant to the research objective.

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This finding is particularly significant given the study's focus on evaluating how AI can enhance resource optimization, waste management, and sustainability across sectors such as manufacturing, supply chain, and urban infrastructure. A reliable measurement tool is essential when assessing complex constructs like technological integration and sustainability practices.

The results support the credibility of the research instrument and affirm that the selected items collectively measure the intended concept effectively. Consequently, further statistical analyses—such as factor analysis, correlation, or regression—can be conducted with confidence in the data's internal consistency.

In summary, the reliability analysis confirms that the research scale is statistically sound, reinforcing the validity of insights drawn from the study on the intersection of AI and Circular Economy practices.

**Descriptive Statistics**

## Descriptives

[DataSet1]

**Descriptive Statistics**

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| AI Awareness & Perception [I am familiar with the concept of a circular economy.] | 677 | 1 | 5 | 3.13 | 1.342 |
| AI Awareness & Perception [I understand the role of AI in promoting a sustainable circular economy.] | 677 | 2 | 5 | 3.34 | .732 |
| AI Awareness & Perception [I believe AI has the potential to reduce waste in industrial processes.] | 677 | 1 | 4 | 2.69 | .890 |
| AI Awareness & Perception [I think AI can improve sustainability practices in my organization.] | 677 | 2 | 4 | 3.26 | .627 |
| Valid N (listwise) | 677 | | | | |

**Descriptive statistics interpretation**

The provided SPSS output presents the descriptive statistics of survey responses related to AI awareness and perception in the context of the circular economy. A total of 677 respondents participated, and the data provides insights into their familiarity, understanding, and beliefs regarding AI's role in promoting sustainability and circular practices.

Four items were assessed:

1. Familiarity with the concept of a circular economy:
   The mean score is 3.13 (on a scale from 1 to 5), indicating a moderate level of awareness among respondents. The standard deviation of 1.342 suggests high variability, implying that while some respondents are highly familiar, others lack understanding of the circular economy.
2. Understanding the role of AI in promoting a sustainable circular economy:
   With a mean of 3.34 and a standard deviation of 0.732, this item shows a relatively higher average agreement compared to the others, indicating that respondents generally recognize AI's potential contribution to sustainability. The lower standard deviation signifies more consistent responses among participants.

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3. Belief that AI can reduce waste in industrial processes:
   This item received the lowest mean score of 2.69, reflecting a more cautious or less confident view of AI's potential to directly reduce waste. The standard deviation of 0.890 shows a moderate spread of opinions, highlighting differing views across the sample population. This could be due to limited exposure to AI-driven waste management applications or skepticism regarding their effectiveness.

4. Belief that AI can improve sustainability practices in organizations:
   The mean score of 3.26 is moderately high, suggesting a positive perception of AI's role in enhancing organizational sustainability. The low standard deviation of 0.627 indicates agreement among respondents.

Overall, these findings illustrate that respondents generally understand the potential of AI in advancing circular economy principles but vary in the depth of their awareness and confidence. The varying standard deviations suggest that some concepts, like general understanding of AI's role, are widely accepted, while others, such as its waste-reduction capabilities, are less uniformly perceived.

These insights are critical for policy makers, business leaders, and researchers to design targeted awareness campaigns, training programs, and investments in AI applications for circular economy adoption. Understanding these perceptions helps bridge the gap between technological potential and practical implementation in sustainability-driven initiatives.

**Correlation**

## Correlations

[DataSet1]

**Correlations**

| | | AI-Driven Waste Minimization [I believe AI-driven systems can significantly reduce waste in my organization.] | AI-Driven Waste Minimization [AI can optimize resource usage and minimize waste in production processes.] | AI-Driven Waste Minimization [I have observed a reduction in waste generation after implementing AI technologies in my processes.] |
|---|---|---|---|---|
| AI-Driven Waste Minimization [I believe AI-driven systems can significantly reduce waste in my organization.] | Pearson Correlation | 1 | .776** | .426** |
| | Sig. (2-tailed) | | .000 | .000 |
| | N | 677 | 677 | 677 |
| AI-Driven Waste Minimization [AI can optimize resource usage and minimize waste in production processes.] | Pearson Correlation | .776** | 1 | .826** |
| | Sig. (2-tailed) | .000 | | .000 |
| | N | 677 | 677 | 677 |
| AI-Driven Waste Minimization [I have observed a reduction in waste generation after implementing AI technologies in my processes.] | Pearson Correlation | .426** | .826** | 1 |
| | Sig. (2-tailed) | .000 | .000 | |
| | N | 677 | 677 | 677 |

**Correlation Analysis Interpretation**

The correlation matrix presented in the SPSS output provides insights into the relationships between three key variables concerning AI-driven waste minimization. The analysis is based on data from 677 respondents and uses Pearson correlation coefficients to assess the strength and direction of relationships between participants' beliefs and observations regarding AI's impact on waste reduction in organizational processes.

The first variable examines the belief that AI-driven systems can significantly reduce waste in an organization.

This belief shows a **strong positive correlation** of **0.776** with the perception that AI can optimize resource usage and minimize waste in production processes. This indicates a high level of agreement among respondents that those who believe in AI's general capability to reduce waste also tend to agree with its effectiveness in resource optimization and waste minimization during production. The **significance value (p = .000)** confirms that this relationship is statistically significant, meaning the correlation is not due to random chance. Additionally, the belief in AI-driven systems' ability to reduce waste is **moderately correlated** with the actual observation of waste reduction after implementing AI technologies, with a correlation coefficient of **0.426**. This suggests that while many participants believe in the potential of AI to reduce waste, the real-world observation of such results is not as strongly aligned. This discrepancy might reflect challenges in AI implementation or the time it takes for its effects to become observable in organizations.

Interestingly, the strongest correlation (**0.826**) is found between the perception that AI can optimize resource usage and minimize waste and the actual observation of reduced waste generation post-implementation. This very strong positive correlation signifies that respondents who understand and agree with AI's potential in operational optimization are also more likely to report tangible improvements in waste reduction. Again, the **p-value of.000** indicates strong statistical significance.

Overall, the findings demonstrate consistent and meaningful relationships between theoretical perceptions and practical outcomes concerning AI's role in waste minimization. The results highlight that employees who understand the strategic benefits of AI in operations are more likely to recognize its positive outcomes. These insights can guide organizations in focusing on awareness-building and practical demonstrations of AI's effectiveness to bridge the gap between belief and observed impact. Moreover, strong correlations reinforce the importance of integrating AI solutions within sustainability and circular economy frameworks to drive measurable improvements in industrial processes.

**Regression**

## Regression

[DataSet1]

**Variables Entered/Removed[a]**

| Model | Variables Entered | Variables Removed | Method |
|---|---|---|---|
| 1 | AI Awareness & Perception [I am familiar with the concept of a circular economy.][b] | . | Enter |

a. Dependent Variable: Overall Impact of AI on the Sustainable Circular Economy [I believe AI will play a key role in achieving a sustainable circular economy.]

b. All requested variables entered.

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .041[a] | .002 | .000 | 1.401 |

a. Predictors: (Constant), AI Awareness & Perception [I am familiar with the concept of a circular economy.]

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The regression analysis investigates whether awareness of the circular economy concept can predict the perceived impact of AI in promoting a sustainable circular economy. The independent variable used is "AI Awareness & Perception" (measured by the statement: "I am familiar with the concept of a circular economy"), while the dependent variable is the belief that AI will play a key role in achieving sustainability.

According to the "Variables Entered/Removed" table, only one predictor was included using the standard "Enter" method, confirming a simple linear regression model. The aim is to determine if familiarity with circular economy principles influences the belief in AI's potential role in sustainable development.

The "Model Summary" provides critical statistics. The **correlation coefficient (R)** is **0.041**, indicating a very weak positive relationship between the two variables. The **R Square** value is **0.002**, meaning that only 0.2% of the variation in belief about AI's impact on sustainability can be explained by awareness of circular economy concepts. The **Adjusted R Square** is **0.000**, highlighting that the model has no significant predictive power when generalized. The **standard error of the estimate** is **1.401**, indicating considerable variability in responses and a weak model fit.

In summary, while awareness of the circular economy is relevant, it alone does not significantly predict whether individuals believe AI can contribute to sustainability. The very low R and $R^2$ values suggest that other factors—such as hands-on experience with AI, organizational readiness, or broader environmental knowledge—may be more influential in shaping such beliefs. Therefore, future studies should consider including a wider range of variables to better capture what influences perceptions of AI's role in driving sustainable development.

**Anova**

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 2.225 | 1 | 2.225 | 1.133 | .288[b] |
| | Residual | 1325.742 | 675 | 1.964 | | |
| | Total | 1327.968 | 676 | | | |

a. Dependent Variable: Overall Impact of AI on the Sustainable Circular Economy [I believe AI will play a key role in achieving a sustainable circular economy.]

b. Predictors: (Constant), AI Awareness & Perception [I am familiar with the concept of a circular economy.]

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 4.032 | .137 | | 29.471 | .000 |
| | AI Awareness & Perception [I am familiar with the concept of a circular economy.] | -.043 | .040 | -.041 | -1.064 | .288 |

a. Dependent Variable: Overall Impact of AI on the Sustainable Circular Economy [I believe AI will play a key role in achieving a sustainable circular economy.]

The ANOVA and Coefficients tables provide further insights into the regression analysis examining the influence of AI awareness on the perception of AI's impact on achieving a sustainable circular economy. The ANOVA table tests whether the regression model significantly predicts the dependent variable. The **F-value** is **1.133** with a **significance level (p-value) of 0.288**. Since the p-value is greater than 0.05, the regression model is **not statistically significant**, indicating that awareness of circular economy concepts does not significantly explain the variance in perceived AI impact on sustainability.

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The total sum of squares is **1327.968**, out of which the regression accounts for only **2.225**, and the residual accounts for **1325.742**. This further shows that the independent variable (AI awareness and perception) explains a negligible proportion of the variation in the dependent variable.
The Coefficients table supports this conclusion. The unstandardized coefficient (**B**) for the independent variable is **-0.043** with a standard error of **0.040**, and the **t-value** is **-1.064**. The **p-value (Sig.) is 0.288**, confirming that the coefficient is not statistically significant. The negative B value suggests a very slight inverse relationship, but given its insignificance, this result is not meaningful.
The **Beta value** (standardized coefficient) is **-0.041**, reinforcing that the predictor variable has a minimal effect on the dependent variable. Meanwhile, the **constant (intercept)** is **4.032**, which represents the expected value of the dependent variable when the predictor is zero.
In conclusion, the regression model does not provide evidence that familiarity with circular economy concepts significantly predicts the belief in AI's role in promoting sustainability. This suggests that other variables should be explored to better understand what drives such perceptions.

## DISCUSSION OF FINDINGS

The comprehensive analysis of the dataset provided insights into participants' awareness of AI, their perception of its role in a sustainable circular economy, and its application in waste minimization. Several statistical tools were employed, including reliability testing, descriptive statistics, correlation, regression, and ANOVA, to evaluate the relationships and predictive power of AI-related perceptions.

The **reliability test** indicated a **Cronbach's Alpha of 0.753**, which signifies an acceptable level of internal consistency among the four items measuring AI awareness and perception. This suggests that the variables used in the survey are reliably measuring a coherent construct.

The **descriptive statistics** showed that among the 677 respondents, the average familiarity with circular economy concepts was moderate (mean = 3.13), while understanding AI's role in promoting sustainability scored slightly higher (mean = 3.34). Interestingly, the belief in AI's ability to reduce waste in industrial processes was relatively lower (mean = 2.69), while confidence in AI's contribution to sustainability practices within organizations was higher (mean = 3.26). These figures reflect varying degrees of understanding and belief in AI's capabilities across different dimensions.

The **correlation analysis** revealed strong positive relationships between the three variables associated with AI-driven waste minimization. Notably, the belief that AI can optimize resource usage was highly correlated with the perception that AI reduces waste generation (**r= 0.826**), and with the belief that AI significantly reduces waste (**r = 0.776**). These results indicate a consistent agreement among respondents regarding the benefits of AI in waste management.

However, the **regression analysis** showed a weak and statistically insignificant relationship between AI awareness and the belief in AI's overall impact on achieving a sustainable circular economy. The **R square value was only 0.002**, indicating that AI awareness explains just 0.2% of the variance in perceptions of AI's impact. The regression coefficient was also negative and insignificant (**p = 0.288**), as confirmed by the **ANOVA test**, which further demonstrated the model's lack of predictive power.
In conclusion, while respondents recognize AI's potential in waste reduction and sustainable practices, general awareness of circular economy concepts does not significantly influence their belief in AI's transformative role. This implies that targeted education or experience with AI applications may be more influential than mere conceptual familiarity.

## CONCLUSION

The study explored the relationship between AI awareness, perception of its capabilities, and its perceived impact on sustainable circular economy practices, particularly waste minimization. The findings provide a nuanced view of how AI is understood and valued in the context of industrial sustainability.

The reliability analysis confirmed that the instrument used to assess AI awareness and perception was statistically sound, with a Cronbach's Alpha of 0.753, indicating acceptable internal consistency. Descriptive statistics revealed that while participants generally had a moderate to high understanding of AI's role in sustainability, there were noticeable differences in how strongly they believed in specific AI applications, such as industrial waste reduction and sustainable practices.

Correlation results showed strong positive relationships among variables related to AI's role in waste minimization. Respondents who believed AI could optimize resource usage also strongly agreed that it could reduce waste and observed benefits from its implementation.

These associations underscore a common perception that AI technologies are effective tools for enhancing efficiency and minimizing waste.

However, the regression and ANOVA analyses revealed a weak and statistically insignificant relationship between general AI awareness (particularly familiarity with the circular economy) and the belief in AI's broader impact on sustainability. With an R-square of just

0.002 and a p-value above 0.05, the model lacked explanatory power, suggesting that familiarity alone may not translate into a belief in AI's transformative potential. Overall, the findings highlight a need for deeper, experience-based engagement with AI technologies to influence perceptions and drive belief in their sustainability impact.