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From Bean to Benefit: Understanding Circular Economy Adoption among Coffee Growers in India

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ABSTRACT

This study explores the awareness, influencing factors, and socio-economic implications of Circular Economy (CE) adoption among coffee growers in India. Despite the increasing global emphasis on sustainability, findings reveal a significant gap in CE awareness, with the majority of growers reporting minimal understanding of CE principles. Peer interactions and non-governmental organizations (NGOs) emerged as primary sources of CE knowledge, while formal institutions like the Coffee Board played a lesser role. Key barriers to CE adoption include low awareness and insufficient technical know-how, overshadowing other factors such as regulation, consumer demand, and scalability. Regression analysis indicates a moderate positive relationship between CE factors and financial outcomes, although many growers perceive CE adoption as financially burdensome. In contrast, social implications show a stronger positive correlation, suggesting that CE practices can enhance community well-being, collaboration, and equity in the coffee value chain. The findings emphasize the need for targeted capacity-building, financial incentives, and policy interventions to promote CE awareness and implementation among smallholder coffee producers.

1. INTRODUCTION

The global coffee industry plays a pivotal role in the agricultural economy, providing employment for millions and significantly influencing international trade dynamics (ICO, 2021). Despite its economic importance, the sector is increasingly scrutinised for its environmental footprint, particularly concerning the substantial waste generated across the value chain. From coffee husks and spent coffee grounds (SCG) to wastewater, the industry's by-products contribute to environmental challenges when improperly managed (Mussatto et al., 2011). These challenges are compounded by the linear production and consumption model prevalent in the sector, characterised by resource extraction, product usage, and waste disposal.

Circular Economy (CE) principles, which advocate for waste minimisation, resource efficiency, and the valorization of by-products, present a transformative approach to addressing these challenges (Geissdoerfer et al., 2017). By integrating CE strategies, the coffee sector can transition toward a more sustainable model that emphasizes recycling, reuse, and recovery. The application of CE in the coffee industry includes practices such as converting waste into bioenergy, compost, and other

valuable materials, thereby creating a closed-loop system (Veleva & Bodkin, 2018).

Natural resource depletion and environmental degradation are the results of the current linear "take-make-waste" extractive methods, which have driven the remarkable expansion of the past centuries. By creating supply chains that are restorative, regenerative, and environmentally benign—by reusing materials and goods, utilizing renewable energy sources, and closing any open loops—the Circular Economy (CE) seeks to address these effects (Baratsas et al., 2021).

Worldwide, coffee is a popular and frequently consumed beverage. Epidemiological studies have shown that coffee lowers the incidence of cancer, non-alcoholic fatty liver disease, and cardiovascular disease. Few studies, however, have investigated the health impacts of discarded coffee grounds (SCG), a byproduct of coffee preparation. Research shows that SCG contain bioactive substances such as caffeine, chlorogenic acids, trigonelline, polyphenols, and melanoidins, which are similar to those in coffee and have health benefits (Bevilacqua et al., 2023). SCG can also reduce global waste, with an estimated 6–8 million tonnes generated annually from coffee production (Bevilacqua et al., 2023).

The processing of coffee generates millions of cubic tons of waste annually. Coffee is a great source of phenolic compounds, melanoidins, and other phytonutrients that offer health advantages. However, coffee waste, often burned, used in animal feed, or dumped in landfills, may harm soil and health due to its high tannin and caffeine concentrations (Arya et al., 2022).The potential for reusing coffee by-products such as coffee pulp, organic waste from pruning, and wastewater from coffee processing is often underestimated. When utilized efficiently, these by-products can enhance productivity and reduce agrochemical use while contributing to natural resource protection (Kerkow, 2021). Proper waste management can also create business opportunities for coffee farmers and cooperatives (Kerkow, 2021).

The coffee sector, under pressure from climate change and production risks, must transition to a CE approach to ensure sustainability. Members across the supply chain must work collectively to adopt circular practices (Smith, 2024).

The CE approach offers an alternative to the traditional linear economic model of high energy consumption and waste. While many examples of CE implementation exist, few focus on complex product value chains like coffee. Research highlights barriers such as incoherent government policies, industry silo thinking, and a lack of standardization, alongside enablers like common vision, effective business models, and fact-based communication (van Keulen, 2020).Coffee by-products such as pulp, husks, silverskin, and SCG are valuable resources for bio-based chemicals, materials, and fuels. Their utilization in packaging, biofuel production, and other applications contributes to recycling strategies within the CE framework (Celli, 2021). SCG specifically have demonstrated potential in reducing energy demands, greenhouse gas emissions, and waste generation (Mayson, 2021).

The CE in the coffee sector emphasizes a shift in economic models to reduce resource pressure and waste while creating new value. Coordination across processes, actors, and scales is critical for achieving this transition (Kampelmann, 2021). Finally, the growth of the coffee shop industry, which has led to increased waste production, underscores the importance of CE approaches for reducing energy use and waste (Ferreira & Carlos, 2020).However, the adoption of CE practices in the coffee industry, particularly in emerging economies like India, remains limited. Factors such as low awareness, technical challenges, and insufficient institutional support hinder the effective implementation of these principles. The Coffee Board of India, a central agency responsible for promoting coffee cultivation and innovation, is uniquely positioned to spearhead efforts toward CE adoption.

This study investigates the potential for CE adoption in the coffee value chain in India, focusing on waste valorization opportunities and the role of institutional mechanisms. By analyzing the enablers and barriers to CE implementation, the research aims to offer actionable insights for policymakers, industry stakeholders, and researchers

Circular Economy in Coffee Supply Chains and By-Product Utilization

The linear "take-make-waste" economic model has significantly driven industrial growth over the past centuries but has also led to the depletion of natural resources and severe environmental degradation (Baratsas et al., 2021). The Circular Economy (CE) model aims to address these issues by fostering restorative and regenerative systems that minimize waste and promote sustainability. In the context of coffee production, CE strategies have the potential to transform the sector by closing material loops, reducing environmental impacts, and enhancing value creation.

Circular Economy Principles and Coffee Supply Chains

Baratsas et al. (2021) highlight how CE principles—reuse, regeneration, and environmental sustainability—can reshape coffee supply chains. By focusing on renewable energy, resource efficiency, and waste minimization, the coffee industry can mitigate the detrimental effects of the linear economy. Similarly, Kerkow (2021) emphasizes the untapped potential of reusing organic waste, such as coffee pulp, pruning residues, and wastewater from processing, which can enhance farm productivity and reduce agrochemical usage. These measures also contribute positively to the carbon cycle and foster natural resource conservation.

The adoption of CE in coffee production requires alignment across supply chain stakeholders. Smith (2024) underscores the

necessity for a collaborative effort among supply chain members to transition toward a CE model. However, achieving this transition is fraught with challenges, including global warming's impact on coffee production and the entrenched "take-make-waste" paradigm.

Utilization of Coffee By-Products

Coffee production generates significant by-products, including coffee pulp, husks, silverskin, and spent coffee grounds (SCG). These materials often end up in landfills or are incinerated, contributing to environmental issues (Arya et al., 2022). However, these by-products hold immense potential for diverse applications in food, energy, and materials science.

Celli (2021) explores the chemical composition of coffee by-products, highlighting their suitability for developing bio-based materials such as packaging and biofuels. These by-products can also be transformed into polymeric matrices or additives, offering properties like antioxidant and antimicrobial activity and enhancing the mechanical resistance of materials (Oliveira, 2021). Sirotiak and Blinová (2017) provide a comprehensive overview of innovative uses for coffee waste, including its application as a sorbent for heavy metal removal, a substrate for biofuel production, and a material for reusable products like cups and compost.

Spent Coffee Grounds (SCG) and Functional Food Development

SCG, a significant by-product of coffee preparation, has garnered attention for its potential in functional food development. Bevilacqua et al. (2023) point out that SCG contains bioactive compounds—caffeine, chlorogenic acids, and polyphenols—which offer health benefits similar to those of coffee. Studies indicate that SCG can improve gut microbiota, reduce energy utilization, and lower the risk of metabolic syndrome. Utilizing SCG could significantly reduce the estimated 6–8 million tonnes of annual waste generated from coffee production.

Arya et al. (2022) caution that while coffee waste offers numerous applications, its high tannin and caffeine concentrations can harm soil quality and animal health if not managed properly. This highlights the need for careful processing and application of SCG to ensure safety and sustainability.

Barriers and Enablers in CE Implementation

Despite the promise of CE, several barriers hinder its implementation in the coffee industry. Van Keulen (2020) identifies key challenges, including fragmented governmental policies, "silo thinking" in industries, and the lack of standardized circular designs. Business model experimentation (BME) in Amsterdam's specialty coffee sector revealed that alignment in vision, coherent policies, and solid business models are crucial for overcoming these barriers. Moreover, the study noted that market perceptions and knowledge dissemination play a significant role in CE adoption. Fact-based communication about CE's benefits can counter misconceptions about linear economies and facilitate a smoother transition.

Mayson (2021) discusses sustainability challenges in the coffee sector, such as high energy demands and greenhouse gas emissions. The study emphasizes the potential of waste-to-energy (WTE) initiatives to achieve a CE, using life cycle analysis to demonstrate reductions in CO2 emissions during coffee roasting. However, the initial costs and complexities of implementing CE systems pose significant obstacles, particularly for small and micro enterprises (Gonçalves et al., 2022).

Social and Financial Dimensions of CE

Padilla-Rivera et al. (2020) highlight the importance of incorporating social aspects into CE research. Their systematic literature review identifies gaps in measuring CE's social impacts, which are crucial for attaining sustainable development. This study emphasizes the role of policy frameworks and community engagement in aligning CE initiatives with societal goals.

Financial aspects also play a pivotal role in CE adoption. Gonçalves et al. (2022) note that the economic viability of circular practices is often constrained by high initial investments, business size, and exposure to financial risks. However, empirical evidence suggests that CE practices can yield economic gains over time, making them a worthwhile investment for companies willing to innovate and adapt.

Coffee Grounds in the Circular Economy

Ferreira (2019) and Celli (2021) explore the diverse applications of coffee grounds within the CE framework. These include their use in biofuel production, active packaging materials, and environmental remediation. Such innovations not only reduce waste but also add value to the coffee supply chain, creating new revenue streams for producers and businesses.

Smith (2024) underscores the urgency of adopting CE approaches in coffee production to mitigate climate risks and ensure long-term sustainability. This requires a shift in mindset across all stakeholders, from growers to consumers, to embrace the principles of reduction, reuse, and recycling.

Toward a Sustainable Coffee Sector

The transition to a CE model in coffee production is both a necessity and an opportunity. While barriers such as financial

constraints, policy fragmentation, and market perceptions persist, enablers like innovation, collaboration, and evidence-based communication can drive progress. By harnessing the potential of by-products and aligning social, environmental, and economic goals, the coffee sector can lead the way in implementing CE practices. This shift not only addresses the environmental challenges posed by the linear economy but also creates a resilient and sustainable future for the industry.

Empirical studies have demonstrated the feasibility of CE in coffee production. Celli (2021) and Sirotiak & Blinová (2017) present examples of valorizing coffee by-products, including their use in biofuel production, composting, and as substrates for biogas and biodiesel. Smith (2024) and Kampelmann (2021) argue for an integrated approach involving all supply chain members, highlighting the importance of coherent policies and solid business models in driving CE adoption.While the potential of CE in the coffee industry is well-documented, several gaps remain. Limited research addresses the sector-specific enablers and barriers to CE adoption, particularly in developing regions. Furthermore, there is a need for comprehensive studies analyzing the role of policy frameworks and institutional support in fostering CE practices. This paper aims to fill these gaps by exploring the perspectives of the Coffee Board of India and examining the social, financial, and ecological dimensions of CE within the coffee value chain.

2. RESEARCH METHOD

This study employs a mixed-methods research design to comprehensively explore the factors influencing the adoption of Circular Economy (CE) practices in the coffee industry. The research focuses on understanding social and financial aspects and the impact of implementing CE practices in the coffee value chain.

The primary objective of this research is to investigate the awareness of Circular Economy practices among coffee growers and identify the critical factors enabling CE within the coffee value chain. Additionally, the study seeks to analyze the financial and social implications of Circular Economy practices within the sector. The perspectives of the Coffee Board of India will be explored to determine their role in facilitating CE adoption and to identify the major factors that influence CE implementation in coffee processing.

A purposive sampling technique will be used to select participants for the qualitative phase, focusing on representatives from the Coffee Board of India who have a deep understanding of the subject. For the quantitative phase, a random sampling method will be employed to collect data from coffee growers and processors who are currently practising CE principles.

Data collection will involve a two-phase approach. The qualitative phase will utilize in-depth interviews with Coffee Board of India representatives, which will be audio-recorded, transcribed, and thematically analyzed to uncover critical insights into CE practices. The quantitative phase will involve administering a structured questionnaire through online surveys to gather data from coffee growers and processors. This phase aims to quantify factors and analyze their relationships to the financial and social impacts of CE.

Qualitative data will be analyzed using thematic analysis to identify patterns and insights, particularly regarding the enabling factors, barriers, and roles of the Coffee Board of India in CE implementation. Quantitative data will be analyzed using descriptive statistics, such as means and standard deviations, to summarize the data. Inferential statistical methods, including Analysis of Variance (ANOVA) and regression analysis, will be employed to examine the relationships between variables and to test the research hypotheses.

Primary data will be collected from coffee growers, processors, and representatives from the Coffee Board of India. These stakeholders are selected to provide diverse perspectives on CE practices, ranging from implementation challenges to observed impacts.

The questionnaire for data collection is adapted from prior research studies on Circular Economy. Constructs focusing on barriers, enablers, and the social and financial aspects of CE are incorporated. Social aspects are drawn from the systematic literature review by Padilla-Rivera et al. (2020), while financial aspects are informed by the study conducted by Gonçalves et al. (2022). Key factors enabling CE adoption in the coffee value chain are based on the research by van Keulen and Kirchherr (2021).

Responses are measured using a five-point Likert scale, with options ranging from "Very Little Extent" to "Very Large Extent." This scale ensures consistency in measuring perceptions and experiences related to CE practices.

The study acknowledges several limitations. First, the subjective nature of qualitative interviews may influence findings due to potential biases in participant responses. Second, the purposive sampling technique for the qualitative phase may restrict the generalizability of the results to other contexts. Finally, the study is delimited to coffee growers, processors, and the Coffee Board of India, potentially excluding other critical stakeholders in the coffee value chain.

3. RESULTS AND INTERPRETATION

Awareness of Coffee Growers About Circular Economy

Interpretation:
The data indicates that awareness of the Circular Economy among coffee growers is notably low. Only six growers reported being aware of the concept "to a very large extent," and 12 growers stated "to a large extent." The majority, 33 growers, acknowledged awareness "to a little extent," suggesting limited familiarity with the concept. Additionally, 11 growers indicated awareness "to a very little extent," implying a lack of understanding about waste management in coffee cultivation. Furthermore, 29 growers responded as neutral, suggesting that while they are aware of the Circular Economy concept, they have neither explored it in depth nor implemented it on their farms.

Source of Awareness

Interpretation:
The analysis of the source of awareness regarding the Circular Economy concept reveals that the farmer community (31%) is the primary source of information for most growers. Non-Governmental Organizations (NGOs) contributed to 20% of the awareness, followed by Farmer Producer Organizations (FPOs) and Farmer Producer Companies (FPCs) at 19%. The Coffee Board of India accounted for 18% of the growers' awareness. Interestingly, 11% of growers stated that they were unaware of reuse and waste management practices in coffee production.

3.1 Key Factors Influencing Circular Economy in the Coffee Value Chain

Descriptive Statistics

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Awareness	91	1	5	2.77	1.136
Know-how Knowledge	91	1	5	2.47	1.139
Consumer Demand	91	1	5	3.16	1.057
Regulation & Tax Incentives	91	1	5	3.10	1.126
Standardization	91	1	5	3.37	1.018
Scalability	91	1	5	3.34	1.128

Interpretation:
The descriptive statistics reveal that "awareness" (M = 2.77) and "know-how knowledge" (M = 2.47) have the lowest mean values, indicating these are key challenges to implementing a Circular Economy in coffee production. Conversely, factors such as consumer demand (M = 3.16), regulations and tax incentives (M = 3.10), standardization (M = 3.37), and scalability (M = 3.34) are not perceived as significant barriers by the growers.

3.2 Financial Implications of Circular Economy Adoption

Model Summary

The regression analysis aimed to assess the impact of Circular Economy (CE) factors on financial outcomes within the coffee value chain. The model summary is as follows:

Statistic	Value
R-value	0.554
R-squared (R^2)	0.307
Adjusted R-squared (Adjusted R^2)	0.299
Standard Error of the Estimate	0.893

Interpretation of Model Summary

The R-value of 0.554 indicates a moderate positive linear relationship between CE factors and financial outcomes. The R-squared value of 0.307 suggests that approximately 30.7% of the variability in financial outcomes is explained by the independent variable (CE factors), indicating a reasonable fit for the model. The Adjusted R-squared value of 0.299 accounts for the number of predictors in the model, providing a more accurate measure of the model's explanatory power.

ANOVA

The Analysis of Variance (ANOVA) results are as follows:

Source	Sum of Squares	df	Mean Square	F-statistic	p-value
Regression	31.420	1	31.420	39.387	<0.001
Residual	70.998	89	0.798		
Total	102.418	90			

Interpretation of ANOVA

The F-statistic of 39.387 with a p-value less than 0.001 indicates that the regression model is statistically significant, meaning that the independent variable (CE factors) significantly explains the variation in the dependent variable (financial outcomes). The p-value being less than the conventional alpha level of 0.05 leads to the rejection of the null hypothesis, confirming the model's validity.

Coefficients

The regression coefficients are as follows:

Variable	B	Standard Error	Beta	t-statistic	p-value
Intercept (Constant)	4.888	0.401		12.183	<0.001
Circular Economy Factors	-0.806	0.128	-0.554	-6.276	<0.001

Interpretation of Coefficients

The regression equation is:

Financial Outcome=4.888−0.806×(Circular Economy Factors)\text{Financial Outcome} = 4.888 - 0.806 \times (\text{Circular Economy Factors}) Financial Outcome=4.888−0.806×(Circular Economy Factors)

The negative slope coefficient (-0.806) indicates an inverse relationship between CE factors and financial outcomes. Specifically, for each unit increase in CE factors, the financial outcome is expected to decrease by 0.806 units. The t-statistic of -6.276 with a p-value less than 0.001 confirms that this relationship is statistically significant.

3.3 Social Implications of Circular Economy Adoption

Model Summary

The regression analysis aimed to assess the impact of Circular Economy (CE) factors on social outcomes within the coffee value chain. The model summary is as follows:

Statistic	Value
R-value	0.492
R-squared (R^2)	0.243
Adjusted R-squared (Adjusted R^2)	0.234
Standard Error of the Estimate	0.70426

Interpretation of Model Summary

The R-value of 0.492 signifies a moderate positive correlation between CE factors and social outcomes. The R-squared value of 0.243 indicates that approximately 24.3% of the variability in social outcomes is explained by the independent variable (CE factors), reflecting a moderate explanatory power of the model. The Adjusted R-squared value of 0.234 accounts for the number of predictors, providing a more accurate measure of the model's explanatory power.

ANOVA

The ANOVA results are as follows:

Source	Sum of Squares	df	Mean Square	F-statistic	p-value
Regression	14.133	1	14.133	28.495	<0.001
Residual	44.143	89	0.496		
Total	58.276	90			

Interpretation of ANOVA

The F-statistic of 28.495 with a p-value less than 0.001 indicates that the regression model is statistically significant, meaning that the independent variable (CE factors) significantly explains the variation in the dependent variable (social outcomes). The p-value being less than the conventional alpha level of 0.05 leads to the rejection of the null hypothesis, confirming the model's validity.

Coefficients

The regression coefficients are as follows:

Variable	B	Standard Error	Beta	t-statistic	p-value
Intercept (Constant)	1.089	0.300		3.632	<0.001
Circular Economy Factors	0.534	0.100	0.492	5.338	<0.001

Interpretation of Coefficients

The regression equation is:

Social Outcome=1.089+0.534×(Circular Economy Factors)\text{Social Outcome} = 1.089 + 0.534 \times (\text{Circular Economy Factors})Social Outcome=1.089+0.534×(Circular Economy Factors)

The positive slope coefficient (0.534) indicates a direct relationship between CE factors and social outcomes. Specifically, for each unit increase in CE factors, the social outcome is expected to increase by 0.534 units. The t-statistic of 5.338 with a p-value less than 0.001 confirms that this relationship is statistically significant.

4. DISCUSSION

The findings of this study underscore the critical role of Circular Economy factors in shaping both financial and social outcomes within the coffee value chain. The inverse relationship between CE factors and financial outcomes suggests that while the adoption of Circular Economy practices may initially pose financial challenges, it is essential for long-term sustainability and profitability. Conversely, the positive relationship between CE factors and social outcomes highlights the potential for Circular Economy practices to enhance social well-being, including improved labor conditions and community development.

These results align with existing literature, which emphasizes the importance of integrating Circular Economy principles to achieve sustainable development in the coffee industry. For instance, a study on the implementation of Circular Economy in the coffee value chain identifies barriers and enablers that influence the adoption of sustainable practices.

This study provides valuable insights into the impact of Circular Economy factors on the financial and social dimensions of the coffee value chain. The findings suggest that while there are challenges associated with the adoption of Circular Economy

practices, the long-term benefits for both financial performance and social well-being are substantial. Future research should explore strategies to mitigate the initial financial challenges and enhance the social benefits of Circular Economy adoption in the coffee industry.

The study provides a comprehensive analysis of the awareness, factors, and impacts of the Circular Economy (CE) among coffee growers. This discussion contextualizes the findings within the broader literature and explores implications for practice and policy in the coffee value chain.

Awareness of the Circular Economy

The results indicate a significant gap in awareness among coffee growers regarding the Circular Economy. A majority of respondents exhibited only a "little extent" (33) or "very little extent" (11) of awareness, with only a few reporting a high degree of understanding (6 to a very large extent). Furthermore, 29 growers responded neutrally, suggesting limited engagement or superficial understanding of CE principles. This lack of awareness aligns with earlier studies highlighting barriers to CE adoption in agribusiness due to insufficient dissemination of knowledge (Geissdoerfer et al., 2017; Kirchherr et al., 2018).

Interestingly, the primary source of CE awareness among growers was identified as peer interactions within the farming community (31%), followed by NGOs (20%), FPOs/FPCs (19%), and the Coffee Board of India (18%). However, 11% of respondents remained completely unaware of CE practices in coffee production. These findings underscore the critical need for targeted outreach and education initiatives to enhance growers' understanding of CE principles.

Key Factors Influencing Circular Economy in the Coffee Value Chain

The descriptive statistics reveal that low awareness ($M = 2.77$, $SD = 1.136$) and insufficient know-how knowledge ($M = 2.47$, $SD = 1.139$) are the most significant barriers to implementing the Circular Economy. Other factors, such as consumer demand, regulation, tax incentives, standardization, and scalability, were less critical according to the growers. This is consistent with previous research suggesting that knowledge gaps often hinder the adoption of CE practices in agriculture (Reike, Vermeulen, & Witjes, 2018). The low mean scores for awareness and knowledge indicate the urgent need for capacity-building programs tailored to coffee growers.

Financial Implications of Circular Economy Factors

The regression analysis ($R = 0.554$, $R^2 = 0.307$, $p < 0.001$) shows a moderate positive relationship between CE factors and financial aspects. The significant F-value ($F = 39.387$, $p < 0.001$) and the negative standardized coefficient ($\beta = -0.554$, $p < 0.001$) suggest that while CE factors influence financial outcomes, the growers perceive the transition to CE as potentially burdensome or cost-intensive. These findings resonate with prior research, which identifies initial costs and perceived financial risks as common concerns among smallholder farmers adopting CE (Lieder & Rashid, 2016). Policymakers must address these concerns through subsidies, incentives, or low-interest financing options to mitigate financial apprehension.

Social Implications of Circular Economy Factors

The analysis of social aspects ($R = 0.492$, $R^2 = 0.243$, $p < 0.001$) highlights a positive relationship between CE factors and social outcomes. The standardized coefficient ($\beta = 0.492$, $p < 0.001$) suggests that adopting CE practices can significantly enhance social well-being. These findings align with the literature emphasizing CE's potential to foster community development, resource-sharing practices, and equitable benefits (Korhonen, Honkasalo, & Seppälä, 2018). The role of NGOs, FPOs, and farmer networks in disseminating CE knowledge further underscores the importance of collective action in promoting sustainable practices.

Implications for Practice and Policy

1. Capacity Building and Awareness Programs: The evident lack of awareness and knowledge calls for structured educational programs and workshops to bridge the gap. Collaborations between the Coffee Board of India, NGOs, and academic institutions can drive these initiatives.
2. Policy Interventions: Financial incentives, such as tax benefits or subsidies, should be introduced to encourage smallholder farmers to adopt CE practices. Standardization efforts could also facilitate scalability and consistency in CE implementation.
3. Community-Based Models: Given the role of farmer networks in spreading CE awareness, fostering community-based models for knowledge sharing can be a cost-effective strategy to enhance CE adoption.
4. Long-Term Research and Monitoring: The findings emphasize the need for longitudinal studies to evaluate the impact of CE practices on both financial and social outcomes, providing evidence-based recommendations for policymakers.

This study highlights critical barriers and facilitators for adopting the Circular Economy in the coffee value chain. While awareness and knowledge remain significant challenges, community-based efforts and targeted policy interventions can drive the transition to sustainable practices. By addressing these barriers, stakeholders can unlock the potential of CE to enhance both economic viability and social equity in the coffee sector.

Study 2:A Qualitative Study of Circular Economy in Coffee Processing: Insights from the Coffee Board of India

Introduction

This study adopts a qualitative research design to explore the factors and role of the Circular Economy (CE) in coffee production and processing, using a case study approach centered on the Coffee Board of India. The Coffee Board serves as an ideal case for examining CE practices due to its significant influence on the coffee industry and its proactive efforts in promoting sustainable practices. Through a comprehensive analysis of the Coffee Board's initiatives, challenges, and outcomes, this study aims to provide a nuanced understanding of CE in the Indian coffee sector.

5. METHODOLOGY

The case study method was employed to collect qualitative data on the Coffee Board of India's CE practices. Data sources included publicly available documents, reports, and interviews with stakeholders involved in CE initiatives. The data was analyzed thematically to identify key factors, challenges, and the role of the Coffee Board in implementing CE.

Findings

Role of the Coffee Board of India in Implementing CE

The Coffee Board of India has played a pivotal role in integrating CE principles into coffee production and processing. Its initiatives include:

1. Innovative Projects:
    - Vermicomposting of coffee waste.
    - Extraction of value-added products like pectin, tannin, and ethanol from coffee waste, supported by the Department of Science and Technology.
2. Financial Support:
    - Direct funding for coffee growers adopting CE practices.
3. Capacity Building:
    - Facilitating workshops and awareness campaigns to educate stakeholders about CE principles and benefits.

These initiatives reflect the Board's commitment to sustainable coffee production, addressing both environmental and economic objectives.

Factors Influencing CE Implementation

The study identified three critical factors influencing CE implementation:

1. Standardization: Establishing uniform practices to ensure consistency in processing and waste management.
2. Consumer Demand: Growing awareness among consumers for sustainable products has driven the adoption of CE.
3. Scalability: Transitioning from pilot projects to broader industry-wide practices remains a challenge.

Post-Implementation Outcomes

The adoption of CE practices has positively impacted profitability and social dimensions, including:

- Enhanced consumer health through sustainable products.
- Improved brand differentiation and competitive advantage.
- Strengthened labor relations and marketing communication.

Challenges in Implementation

Despite progress, the Coffee Board faces several challenges in scaling CE practices:

1. Technological Barriers: Limited access to advanced technology for waste repurposing.
2. Awareness Gaps: Insufficient knowledge among growers about CE benefits.
3. Data Gaps: Lack of comprehensive data to quantify economic benefits.

However, the absence of regulatory barriers and strong governmental support offers an enabling environment for CE practices.

Case Examples of CE in Coffee Processing

The following cases illustrate successful CE applications:

1. Thinkshroom: Used spent coffee grounds (SCG) to grow gourmet mushrooms, achieving an 80–90% bio-efficiency.
2. Curly Brews: Produced eco-friendly coffee mugs from coffee husks.
3. Rasulpur Coffee Estates & Roasters: Developed "Coffee Tea" from pulp and adopted recyclable packaging.
4. Harmakki Coffee: Converted used coffee grounds into daily-use products.

These examples demonstrate how CE practices transform waste into valuable resources, creating new economic opportunities.

Perspectives of Stakeholders

Stakeholders, including processors and growers, emphasized the need for:

1. Government Support: Financial incentives, infrastructure development, and policy frameworks.
2. Awareness Programs: Educating stakeholders on CE practices and their benefits.
3. Supply Chain Integration: Establishing a full-circle supply chain to maximize resource utilization.

This qualitative study highlights the transformative potential of Circular Economy practices in the Indian coffee sector, as demonstrated by the Coffee Board of India. The case study approach underscores the importance of innovation, stakeholder engagement, and government support in overcoming challenges and scaling CE initiatives. By adopting CE principles, the coffee industry can achieve sustainability, enhance profitability, and address pressing environmental concerns. Future research can focus on quantifying the economic and environmental benefits of CE practices to further validate these findings.

Theoretical Implications

This qualitative study contributes to the growing body of knowledge on Circular Economy (CE) and its application in the coffee industry, particularly in the context of developing economies. Theoretical implications of this study include:

1. Advancement of CE Theory in Agribusiness:

By examining CE practices in coffee production and processing, this study provides insights into how CE principles can be adapted to agricultural and plantation sectors, addressing specific challenges like waste management and resource efficiency.

2. Integration of Social and Economic Perspectives:

The findings highlight the dual benefits of CE—economic profitability and social well-being—providing a holistic view of its implementation. This integration broadens the scope of CE theory, linking sustainability with consumer health, labor relations, and market competitiveness.

3. Framework for Resource Repurposing:

The study identifies key factors—standardization, consumer demand, and scalability—as critical to implementing CE. These factors serve as a theoretical framework for evaluating and scaling CE practices in similar industries.

4. Case-Based Validation of CE Models:

Through detailed case examples, this study validates theoretical models of CE by showcasing real-world applications like vermicomposting, waste-to-value products, and sustainable packaging in the coffee sector.

5. Policy Implications for CE Research:

The role of governmental and institutional support in enabling CE practices offers insights for policy-focused research, emphasizing the importance of infrastructure, incentives, and regulatory frameworks.

Practical Implications

The study also provides actionable insights for industry practitioners, policymakers, and researchers aiming to implement and scale CE practices in agribusiness:

1. Adoption of CE Practices:

Coffee growers and processors can adopt innovative CE practices such as converting spent coffee grounds into valuable products (e.g., mushrooms, tea, and packaging materials) to generate secondary income and enhance sustainability.

2. Policy Design and Incentives:

Governments and regulatory bodies can design policies to encourage CE adoption by providing financial support, tax incentives, and funding for infrastructure development, such as waste management facilities and recycling centers.

3. Capacity Building and Awareness:

Workshops and training programs can bridge knowledge gaps, educating stakeholders on the economic and environmental benefits of CE practices. Awareness campaigns can also influence consumer behavior, driving demand for sustainable coffee products.

4. Market Competitiveness:

Implementing CE practices can help companies differentiate their brands by emphasizing sustainability, thereby enhancing their market position and attracting environmentally conscious consumers.

5. Supply Chain Integration:

Establishing a circular supply chain, from waste collection to repurposing, can maximize resource utilization and reduce environmental impact. This requires collaboration among growers, processors, and logistics providers.

6. Scalability Strategies:

The study highlights the importance of scaling pilot projects into industry-wide practices. Stakeholders can achieve scalability by investing in technology, standardizing processes, and leveraging government and institutional support.

7. Future Research and Collaboration:

Researchers can build on the findings to explore the economic benefits of CE practices quantitatively. Collaboration between academia, industry, and government can further enhance the implementation and innovation of CE practices in agribusiness.

By addressing both theoretical and practical dimensions, this study underscores the transformative potential of CE in the coffee industry, offering a roadmap for sustainable growth and environmental stewardship.

Future Research Directions

This study lays the foundation for further exploration of Circular Economy (CE) practices in the coffee industry, highlighting several avenues for future research:

While this study provides qualitative insights, future research can focus on quantitative analyses to measure the economic impact of CE practices. Studies can examine metrics such as cost savings, revenue generation, and return on investment at various stages of the coffee production and processing cycle.Longitudinal Studies on CE Adoption: Long-term studies are needed to evaluate the sustainability and scalability of CE practices over time. Such research could explore the progression of pilot projects, their impact on local communities, and the evolution of market demand for CE-based products.

6. CONSUMER

Research can investigate how consumer preferences influence the adoption of CE products in the coffee sector. Studies can examine the willingness to pay a premium for sustainable products and the role of branding and marketing in shaping consumer perceptions.

Conducting cross-regional studies would provide insights into how geographical, cultural, and economic factors affect the implementation of CE practices. Comparing India's coffee sector with other coffee-producing nations could uncover best practices and unique challenges.Future research could delve into the development and application of advanced technologies for waste conversion, resource optimization, and process automation. Examples include using AI and IoT for monitoring waste management and optimizing circular supply chains.Further exploration is needed on the role of government policies, institutional support, and public-private partnerships in promoting CE practices. Research can assess the effectiveness of specific policies, subsidies, and financial incentives in accelerating CE adoption.Investigating the social implications of CE practices, such as improved labor relations, community empowerment, and health benefits, would provide a more comprehensive understanding of its broader impact.

Future studies could explore the integration of CE principles with other sustainability frameworks, such as ESG (Environmental, Social, Governance) criteria, Sustainable Development Goals (SDGs), and regenerative agriculture practices.Building on the findings from the coffee sector, researchers could expand their focus to other crops and industries, identifying transferable practices and sector-specific challenges in implementing CE.Future research can work on establishing standardized metrics and indicators to measure the success and impact of CE practices. This would enable stakeholders to evaluate progress effectively and make data-driven decisions.Examining the role of startups and

entrepreneurs in driving innovation and scaling CE practices can provide insights into fostering an ecosystem that supports circular solutions in the agribusiness sector.

By addressing these research gaps, future studies can deepen the understanding of CE practices and their transformative potential in not only the coffee sector but also the broader agricultural and industrial landscape. These insights will further aid policymakers, industry practitioners, and researchers in building a sustainable and circular economy

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