

Navigating Challenges for Circular Grape Supply Chains: Blockchain, Business Ethics, and Socio-Economic Sustainability in Farmer Producer Companies of Maharashtra

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Abstract

The adoption of circular economy principles and Blockchain technology presents a promising avenue for enhancing sustainability and efficiency within agricultural supply chains. This paper explores the intersection of circular grape supply chains, Blockchain technology, business ethics, and socio-economic sustainability, aiming to uncover synergies and implications for industry stakeholders. By analyzing existing literature and identifying gaps, this study sets the stage for future research in this critical domain. The research methodology employed a qualitative approach, utilizing in-depth interviews with stakeholders deeply engaged in grape supply chains in Maharashtra, including farmers and employees of Farmer Producer Companies (FPCs). Findings reveal complex challenges within the grape trade sector, ranging from operational inefficiencies to trust deficits and technological limitations. Key insights include the recognition among stakeholders of the potential benefits of Blockchain for transparency and traceability, albeit hindered by implementation complexities. Critical issues identified through interviews include fluctuating prices impacting farmer revenues, payment delays eroding trust, and the need for improved stakeholder engagement and collaboration. Stakeholders emphasized the necessity of user-friendly solutions and improved communication to facilitate technology adoption and sustainable partnerships. Looking forward, future research directions include exploring alternative governance structures, assessing the sustained impact of Blockchain adoption on supply chain efficiency, and analyzing policy frameworks to facilitate innovation and collaboration. Cross-sectoral collaborations could unlock transformative changes in agricultural supply chain management, driving positive outcomes for sustainability and efficiency.

Keywords: Circular economy, Blockchain technology, Grape supply chains, Business ethics, Socio-economic sustainability, Stakeholder engagement

1. Introduction:

The grape industry in India, centered in Maharashtra, Karnataka, and Mizoram, relies on complex supply chains influenced by various factors. Grapes is cultivated in an area of 171 thousand hectares and production of 3781 thousand MT (source: NHB, 2023-24 first advance estimate). Maharashtra ranks first in terms of production followed by Karnataka. In 2021-22, grapes covered 2.30% of the total fruit production area in India, spanning 161.91 thousand hectares. India is a significant exporter of fresh grapes globally, with exports reaching 267,950.39 metric tons valued at Rs. 2,543.42 crores or 313.70 USD million during 2022-23. Major export destinations for Indian grapes in 2022-23 included the Netherlands, Bangladesh, the United Arab Emirates, the United Kingdom, and Russia (Grapes, APEDA, 2024). The grape industry plays a vital role in the global economy, supporting millions of livelihoods and contributing significantly to international trade. However, conventional linear grape supply chains, characterized by a take-make-dispose model, are increasingly scrutinized for their environmental and social impacts. Concerns regarding unethical labor practices, unfair trade practices, trust issue between farmers and exporting firms particularly related to pricing and export, inaccurate information, lack of traceability tools, market inefficiencies, pesticide use, water scarcity, and waste generation are pushing stakeholders towards more sustainable solutions (Dr. Kaushik Banerjee, 2023).

Circular economy principles, emphasizing resource efficiency, waste reduction, and closed-loop systems, have gained traction as a holistic approach to tackling these challenges. Furthermore, the integration of Blockchain technology holds promise for enhancing transparency, traceability, and trust within supply chains. This paper investigates the nexus between circular grape supply chains, Blockchain technology, business ethics, and socio-economic sustainability, aiming to uncover synergies and implications for industry stakeholders. By identifying current literature and industry gaps, this paper will pave the way for future research directions in this critical domain.

2. Review of Literature

2.1. Circular Grape Supply Chains:

Supply chain management is crucial for modern businesses, indicating organizational performance, success, efficiency, and responsiveness, particularly for financial benefits and sustainability (Zhang, J., Thomas 2019). Table grapes are highly temperature-sensitive, affecting their quality through taste, shelf-life, and price. However, shipping them long distances from warm-climate countries to cold-climate countries poses challenges in maintaining temperature in the export cold chain. Produce losses occur at various stages of the supply chain, with losses mainly occurring at supermarket and consumer stages in developed countries and post-harvest and distribution stages in developing countries. Temperature breaks throughout the cold chain, especially in transport and retail stages, can significantly affect product sensory quality (Goedhals-Gerber, L. L., 2024).

Circular economy principles aim to minimize waste and maximize the value of resources by keeping them in use for as long as possible. In this context, the role of Farmer Producer Companies (FPCs) emerges as pivotal in fostering a circular economy within grape supply chains. FPCs play a crucial role in implementing efficient sorting and packaging practices within grape supply chains (Mukherjee, A. A., 2022). By employing modern technologies and best practices, FPCs can ensure that only high-quality grapes reach the market, minimizing wastage and enhancing market competitiveness. Moreover, innovative packaging solutions, such as biodegradable materials or reusable containers, can be adopted to reduce the environmental footprint of packaging activities.

Facilitating exportation and enhancing market access are key functions of FPCs in the grape industry. Jothikumar, R. (2021) highlighted in their paper that through collaborative efforts, FPCs can negotiate better trade deals, establish direct links with international buyers, and adhere to stringent quality standards demanded by global markets. By streamlining export processes and promoting sustainable practices, FPCs can position Indian grapes as premium products in the global marketplace. FPCs serve as platforms for training and capacity building among grape farmers. By organizing workshops, seminars, and skill development programs, FPCs empower farmers with the knowledge and expertise to adopt sustainable farming practices, improve productivity, and mitigate environmental impacts. Training initiatives may encompass aspects such as organic farming techniques, water conservation methods, and integrated pest management strategies.

Efficient utilization of grape waste is imperative for fostering a circular economy. FPCs can explore innovative solutions such as converting organic waste into electricity through biomass conversion technologies. Additionally, composting techniques can be employed to transform grape pomace and other organic residues into nutrient-rich fertilizers, thereby closing the loop in the agricultural cycle. Furthermore, initiatives like resin making from grape stems or bioplastics from grape skins demonstrate the potential to extract value from waste streams.

2.2. Blockchain Technology adoption in Grape Supply Chains:

Supply chains are grappling with issues due to insufficient trust in data sharing, prompting a paradigm shift towards Blockchain technology. Blockchain technology facilitates more secure and effective data sharing, fostering mutual trust among parties who may question each other's data, thereby enhancing business partnerships' trust (Al-Rakhami, M. S., & Al-Mashari, M. 2021). Blockchain technology plays a critical role in overseeing supply chain operations and providing a financially viable option (Meidute-Kavaliauskiene, 2021). It effectively addresses challenges inherent in IoT solutions dependent on centralized cloud infrastructures, including issues related to identity fraud, privacy, and compromised reputation management (Jabbar, S., Lloyd, 2021). Through the integration of Blockchain across both upstream and downstream segments of the supply chain, organizations can facilitate secure data exchange, mitigate information asymmetry, and safeguard the privacy of stakeholders (Sharma, S., Kumar, 2021). Moreover, Blockchain technology fosters trust among market participants, particularly evident in agricultural supply chains where it cultivates trust-based relationships. This technological advancement is instrumental in overcoming obstacles associated with conventional centralized networks, thereby enhancing the overall efficiency of the supply chain ecosystem.

Blockchain technology has emerged as a transformative force across various industries, offering unprecedented transparency, traceability, and efficiency in supply chain management. In the grape industry, where quality control and provenance are paramount, integrating Blockchain technology presents a significant opportunity for enhancing trust and accountability. Blockchain technology can enhance trust in business by transforming trust from a low-trust centralized authority to a high-trust decentralized network. Its features include immutability, security, consensus, and auditing, making it a secure platform for data sharing (Nasir, N. M. et al. 2022).

Farmer Producer Companies (FPCs) in India stand poised to leverage Blockchain solutions to revolutionize grape supply chains and unlock benefits for farmers. FPCs play a crucial role in spearheading the adoption of Blockchain technology within grape supply chains. They serve as intermediaries between grape farmers and other stakeholders, facilitating the implementation and integration of Blockchain platforms. FPCs can collaborate with technology partners to customize Blockchain solutions tailored to the specific needs and complexities of grape cultivation, harvesting, processing, and distribution.

Key areas where FPCs can lead the implementation of Blockchain technology include:

- **Food Safety and Ethical Agricultural Practices:** Blockchain can revolutionize food safety by providing a transparent and immutable ledger of food production and distribution. FPCs can utilize Blockchain to track the journey of food products from farm to table, ensuring compliance with ethical agricultural practices and food safety standards. This can help in identifying and addressing issues such as contamination, fraud, and unethical practices in the supply chain (Yap, T.L., Nayak, R.2023)
- **Traceability and Provenance:** Blockchain enables end-to-end traceability of grapes, allowing stakeholders to track the journey of each grape bunch from farm to table. FPCs can leverage Blockchain to record vital information such as cultivation practices, harvesting dates, storage conditions, and transportation routes. By ensuring full transparency and immutable records, FPCs can enhance consumer trust and confidence in the quality and authenticity of Indian grapes (Sharma, A., Bhatia, T., Singh, R. K., & Sharma, A. 2024).
- **Quality Control and Compliance:** Through Blockchain-enabled smart contracts, FPCs can establish quality parameters and compliance standards for grape production. Smart contracts can automatically execute predefined actions or payments based on predefined criteria, such as meeting specific quality benchmarks or adhering to sustainability certifications. This incentivizes farmers to uphold high standards while ensuring fair compensation for their efforts (Yap, T.L., Nayak, R., 2023).
- **Supply Chain Efficiency:** Blockchain streamlines supply chain operations by reducing paperwork, minimizing errors, and eliminating intermediaries. FPCs can leverage Blockchain's decentralized ledger to optimize logistics, reduce transaction costs, and expedite payments along the grape supply chain. By automating processes such as invoicing, inventory management, and payments, FPCs can improve operational efficiency and profitability for farmers (Chu, T. T., & Pham, T. T. T. 2024).
- **Business Performance:** Implementing Blockchain technology can improve the overall performance of FPCs by optimizing supply chain processes, reducing operational costs, and enhancing efficiency. By streamlining data management and facilitating seamless collaboration among supply chain partners, Blockchain can help FPCs achieve greater operational agility and competitiveness in the market (Yap, T.L., Nayak, R.2023).
- **Address coordination challenges:** Blockchain technology has emerged as a potential solution to address coordination challenges in the agri-food supply chain. It enhances trust between network actors, eliminates intermediaries through peer-to-peer exchange of food products, and provides transparency among agents. It also enhances traceability and visibility of supply networks. Blockchain also reduces transaction costs by reducing bounded rationality and information asymmetries, making it suitable for supply chain operations and management. Despite the lack of research on its effective application, Blockchain technology is promising for improving supply chain operations and management (Kramer, M. P.2024, Chu, T. T., & Pham, T. T. T. 2024).

The adoption of Blockchain technology through FPCs brings forth a multitude of benefits for grape farmers such as, Fair Pricing and Payment Transparency, Market Access and Brand Enhancement, Risk Mitigation and Sustainability.

2.3. Business Ethics in Grape Supply Chains:

Business ethics play a critical role in shaping the grape supply chain, encompassing fair trade practices, environmental sustainability, and social responsibility (Krishnan, R., Yen, P. 2021). Farmer Producer Companies (FPCs) in India serve as key intermediaries in grape cultivation, processing, and distribution, wielding considerable influence over ethical practices within the industry.

- **Fair Trade Practices:** One of the cornerstones of business ethics in grape supply chains is ensuring fair trade practices that prioritize equitable treatment of farmers and workers. FPCs play a vital role in negotiating fair prices for grape produce, transparently communicating pricing mechanisms, and ensuring timely payments to farmers. By fostering transparent and mutually beneficial relationships between grape growers and buyers, FPCs uphold the principles of fairness and integrity in business transactions.

- **Environmental Sustainability:** Environmental sustainability is paramount in grape cultivation, as it directly impacts ecosystem health, soil fertility, and water resources. FPCs have a responsibility to promote sustainable farming practices among their member farmers, such as organic farming methods, water conservation techniques, and biodiversity preservation. By implementing environmentally friendly initiatives and adhering to sustainability standards, FPCs mitigate the ecological footprint of grape production and contribute to long-term environmental stewardship.
- **Social Responsibility:** Grape supply chains also have social implications, particularly concerning the welfare and livelihoods of farmers and local communities. FPCs can proactively address social issues by prioritizing the well-being of farmers, ensuring safe working conditions, and fostering community development initiatives. Moreover, FPCs can promote gender equality and empowerment by actively involving women farmers in decision-making processes and providing them with access to resources and opportunities.
- **Transparency and Accountability:** Transparency and accountability are fundamental pillars of business ethics, fostering trust and confidence among stakeholders. FPCs can enhance transparency by maintaining open communication channels, disclosing relevant information about pricing, quality standards, and supply chain practices. Additionally, FPCs can implement robust monitoring and auditing mechanisms to ensure compliance with ethical guidelines and regulatory requirements, thereby holding themselves accountable for their actions.
- **Mitigating Ethical Risks:** Ethical risks such as child labor, exploitation of migrant workers, and unfair labor practices pose significant challenges within grape supply chains. FPCs must actively identify and address these risks through rigorous due diligence processes, supplier assessments, and capacity-building initiatives. By promoting ethical labor practices and human rights standards, FPCs safeguard the dignity and well-being of all individuals involved in grape production and distribution.

Blockchain technology, with its immutability and transparency, can significantly impact organizational interactions. It reduces the power of managers to control business transactions, preventing fraud and personal use. Blockchain also promotes ethical codes like honesty, consideration, and responsibility, enabling accurate tracking of executive services and asset valuation. The distributable information system in Blockchain networks can enhance organizational competition, align with human and citizenship rights, and build a strong technocratic power structure. The use of hash and encryption functions promotes social trust and network-level coordination. Blockchain can also address ethical challenges in data-driven science (Ronaghi, M. H. (2021), Tapscott, D., & Tapscott, A. (2017), Ronaghi, M. H., & Mosakhani, M. (2022).

2.4. Socio-economic Sustainability:

The convergence of circular practices and Blockchain integration within grape supply chains presents a compelling narrative for sustainable socio-economic development, especially with the active involvement of Farmer Producer Companies (FPCs). This innovative approach not only aligns with the overarching sustainability objectives of the industry but also offers tangible benefits to stakeholders, ranging from enhanced profitability to long-term resilience against market fluctuations (Rainero, C., & Modarelli, G. 2021).

Circular grape supply chains, facilitated by FPCs, offer opportunities for smallholder farmers to enhance their livelihoods. By embracing sustainable farming practices and efficient resource utilization, farmers can increase productivity, reduce production costs, and improve their income. Additionally, Blockchain integration ensures fair pricing, transparent transactions, and timely payments, thereby empowering farmers economically and enhancing their financial stability. Moreover, initiatives such as waste utilization and value-added product development create additional income streams for farmers, contributing to overall socio-economic development in rural areas (Upadhyay, A., Mukhuty., 2021).

Circular grape supply chains promote inclusivity and provide marginalized communities with greater access to markets. FPCs play a crucial role in bridging the gap between smallholder farmers and market opportunities, facilitating collective marketing efforts and negotiating fair trade agreements. Through Blockchain-enabled traceability, consumers can access information about the origin and production practices of grapes, fostering trust and demand for ethically sourced products. This enhanced market access not only increases revenue for farmers but also empowers marginalized communities by providing them with a platform to showcase their products and skills on a broader scale (Venkatesh, V. G., 2020).

The adoption of circular practices in grape supply chains, coupled with Blockchain integration, contributes to reducing the environmental footprint of agriculture. Sustainable farming methods promoted by FPCs, such as organic farming, water conservation, and agro-forestry, minimize chemical inputs, preserve natural resources, and mitigate greenhouse gas emissions. Furthermore, initiatives like waste recycling, composting, and renewable energy generation from grape waste contribute to closing the resource loop and promoting a more circular economy. By prioritizing environmental stewardship, FPCs ensure the long-term viability of grape cultivation while safeguarding ecosystem health and biodiversity.

Despite the numerous benefits associated with socio-economic sustainability initiatives in grape supply chains, challenges and trade-offs exist. Smallholder farmers may face barriers such as limited access to technology, financial resources, and market information, hindering their ability to fully participate in circular practices. Additionally, transitioning to sustainable farming methods may entail initial costs and productivity adjustments, posing challenges for farmers accustomed to conventional practices. Moreover, balancing economic viability with social and environmental objectives requires careful planning, stakeholder engagement, and policy support to address competing interests and trade-offs effectively.

3. Practical Challenges of Blockchain technology adoption, Circular Supply Chain practices and Business Ethics:

India's Agricultural Supply Chains (ASCs) are intricate and interconnected, prompting consideration of Blockchain technology as a potential remedy. However, its adoption in ASCs remains nascent due to several challenges. These include the complexity of design, stakeholder resistance, lack of trust among Farmer Producer Companies (FPCs) and farmers, and the substantial resources and initial capital investment required.

Challenges also stem from farmers' limited technological expertise, design intricacies, and resistance to cultural shifts. Moreover, there's skepticism among agro-stakeholders regarding the reliability of Blockchain-based systems. The energy consumption and infrastructure demands of Blockchain systems further compound the issue, necessitating significant initial capital investment.

Circular supply chain practices and business ethics present additional hurdles. Farmers may struggle with understanding quality certification procedures, fair trade practices, and stakeholder engagement. FPC networks rely on distribution channels for timely record updates, but lack of dedication and promptness in implementation slow progress. In summary, while Blockchain holds promise for enhancing ASCs, it encounters obstacles such as usability, design complexity, stakeholder resistance, and financial investment requirements. Table 1 & 2 scrutinize industry gaps concerning the implementation of Blockchain technology, circular supply chain practices, and business ethics, elucidating significant challenges as identified in literature and expert opinions.

Sr. No	Challenges	Explanation	References
Blockchain technology adoption			
1	Ease of use and Awareness	Farmers, among other stakeholders, often lack significant technological expertise, making the operation of Blockchain-based systems difficult for them.	Expert Opinion, Yap, T.L., Nayak, R.(2023), Sharma, A., Bhatia, (2024)
2	Design complexity	The presence of coding flaws or vulnerabilities represents significant concerns in Blockchain-based systems, necessitating a high level of skill in system design for optimal functionality.	(Iansiti and Lakhani, (2017); Ibrahim, D. (2023), Jabbar, S., Lloyd, (2021), Expert Opinion
3	Stakeholder resistance	The intermediaries within the agricultural supply chain may show resistance towards adopting Blockchain technology, as cultural shifts can often present challenges.	Expert Opinion, Jabbar, S., Lloyd (2021).
4	Lack of trust among FPC and Farmers and other stakeholders	There is a prevailing skepticism among agro-stakeholders regarding the utilization of Blockchain-based systems.	Expert Opinion, Jabbar, S., Lloyd , 2021, Nasir, N. M, 2022)
5	Substantial resources and significant initial capital investment.	The Blockchain-based system consumes a significant amount of energy and necessitates substantial infrastructure. Setting up this infrastructure requires a considerable initial investment of capital.	(Ibrahim, D. (2023); Kshetri, 2019; Zhao et al., 2019; Thakur et al., 2019)

Table 1: Practical Challenges of the Blockchain Technology Adoption

Sr. No	Challenges	Explanation	References
Circular supply chain practices and Business ethics			
1	Quality Certification procedure	Farmer inability to understand quality Certification procedure requirement by agencies like APEDA and considerable time duration for it, leads to lack of trust and rush to sell in local market	Expert Opinion
2	Fair trade practices	Previous experience by farmer and delay in different procedure right from procurement to payment, pricing issue (communicated vs actual received)	Expert Opinion
3	Stakeholder involvement	Participation of famers and community in decision making process, pricing, distribution, alternate market access	Expert Opinion, Nasir, N. M (2022). Thakur et al., 2019.
4	FPC Network Dependence	FPC more dependent on distribution network for timely updating of records, global market changes affect exports, farmer resorting to local market	Expert Opinion
5	Unfitting supply chain practices implementation	FPC having plan ready for reduction of wastage and using resources efficiently (taken from leading firms) however lags in implementation, dedication by support system and promptness issue (not modified as per FPC capability).	Expert Opinion

Table 2: Practical Challenges of the Circular Supply Chain Practices and Business Ethics

4. Methodology:

The study employs a qualitative research approach to delve deeply into the subject matter, aiming to grasp comprehensive insights. Qualitative interviews are the chosen method as they facilitate a nuanced exploration of perspectives, experiences, and knowledge from various stakeholders. The participants for these interviews will be carefully selected using purposive sampling, with a focus on individuals deeply engaged in the grape supply chain in Maharashtra. This will include farmers, employees, and members of the community actively involved in managing or working within Farmer Producer Companies (FPCs). Selection criteria will include a minimum of 3 years of involvement in FPC operations, experience in management, governance, or advisory roles within FPCs, as well as demonstrated knowledge or involvement in initiatives related to Blockchain technology or promoting business ethics and socio-economic sustainability within FPCs.

4.1. Data Collection:

Our study employed individuals as the subjects of observation and analysis. Our study employed individuals as the subjects of observation and analysis. A total of 18 interviews were conducted, comprising farmers and employees of Farmer Producer Companies (FPCs) with substantial experience in grape supply chains in Maharashtra. Details regarding the sample characteristics can be found in Table 3.

The interviews were conducted on-site at the participants' workplaces, ensuring a familiar and comfortable environment for discussion. Each interview session lasted approximately 45 minutes, allowing for in-depth exploration of the topics. To ensure consistency and facilitate more structured responses, participants were provided with the interview questions in advance via email. This allowed them to prepare and organize their thoughts for each question, enhancing the quality and depth of the discussions. For farmer participants (only registered with FPC), contact was made on-site, and the purpose of the study was briefly explained before initiating the discussion. This approach ensured transparency and helped establish rapport with the participants, fostering open and candid conversations about their experiences and perspectives within the grape supply chain ecosystem.

Interviewee code	Job positions	Industry/Discipline sector	Years of experience
1	Manager - Operations	FPC	10
2	Sr. Manager –Supply chain	FPC	12
3	Managing Director	FPC	17
4	Manager - Warehouse	FPC	8
5	Assistant - Warehouse	FPC	3
6	Executive - Logistics Services	FPC	7
7	Senior Executive - Operations	FPC	4
8	Senior Executive - Logistics & Warehousing	FPC	9
9	Senior Executive - Packaging	FPC	7
10	Manager - Marketing	FPC	4
11	Executive – R&D Farms	FPC	3
12	Assistant – R&D Farms	FPC	5
13	Farmer	Dealing with FPC for grape trade	4
14	Farmer	Dealing with FPC for grape trade	7
15	Farmer	Dealing with FPC for grape trade	5
16	Farmer	Dealing with FPC for grape trade	5
17	Farmer	Dealing with FPC for grape trade	3
18	Farmer	Dealing with FPC for grape trade	2

Table 3. Description of the sample selected for interview.

The key interview questions are presented below:

- For Employees of FPC (questions were asked in local language)
 - What does the grape supply chain refer to, and how does it involve farmers in Maharashtra?
 - How circularity is achieved in supply chain? What are the challenges the company faces in implementing it?
 - How is Blockchain technology applied in the grape supply chain? What are the advantages and challenges associated with its implementation?
 - How challenging is it to uphold ethical practices while navigating uncertainties stemming from farmers, technology adoption, and other stakeholders in the supply chain?
 - Do you believe that the use of Blockchain technology enhances sustainability practices and promotes business ethics?
 - In what ways does the grape supply chain contribute to socio-economic sustainability in Maharashtra? How are sustainable practices integrated into the supply chain?
- For Farmers registered with FPC (questions were asked in local language)
 - How long have you been working with the Farmer Producer Company (FPC)? Can you share your experience of working with them over this period?
 - What are some of the key benefits you have observed from working with the FPC? Are there any specific advantages that have impacted your farming operations or livelihood positively?
 - What challenges do you face while working with the FPC? Are there any difficulties or issues that you encounter regularly?
 - In your opinion, what improvements or changes would you suggest to enhance the relationship and collaboration between farmers and the FPC?
 - Have you heard about Blockchain technology being used in agricultural supply chains like grape production? If yes, what do you understand about it?
 - Have you encountered any issues related to fair treatment, transparency of procedures, availability of price information, fulfillment of promises made by the FPC, or any social concerns while working with them? Could you share any specific instances or concerns you've noticed?

The formulation of these interview questions was guided by a thorough review of the current body of literature. We carefully crafted these questions to gather extensive data on Farmer Producer Companies (FPCs), their practices, Blockchain implementation, sustainability impact, and related topics. This analysis was conducted to shed light on the research question and address the identified research gap effectively.

5. Discussion:

In delving into the dynamics and challenges of the agricultural supply chain, particularly in the grape trade sector, it becomes evident through interviews with both stakeholders and farmers that numerous complexities exist. These complexities span from operational inefficiencies to technological limitations, reflecting broader issues within the industry.

A significant aspect highlighted in the interviews was the recognition among employees, particularly within Farmer Producer Companies (FPCs), of contemporary practices such as Blockchain technology and the imperative to integrate ethical considerations into their operations. As one FPC manager remarked, "We are aware of the potential benefits of Blockchain in enhancing transparency and traceability, but implementation remains a challenge due to the complexity of our existing systems and the need for timely data entry".

Conversations with farmers underscored a pervasive sentiment of uncertainty stemming from interactions with FPCs and the broader supply network. "We often experience fluctuating prices due to changes in export regions and quality certification requirements (like APEDA certificates)," noted one farmer. Such fluctuations not only affect farmer revenues but also impact their trust in the FPCs they rely on for market access.

Payment methods and durations emerged as critical concerns voiced by both employees and farmers. A senior supply chain manager expressed frustration: "Delayed payments to farmers create distrust and hinder our ability to maintain stable relationships. We must address this for sustainable partnerships." Farmers echoed this sentiment, emphasizing the importance of reliable cash flows for their livelihoods.

Stakeholder involvement was cited as a crucial factor influencing operational efficiency and trust. The Managing Director of an FPC emphasized, "Engagement with all stakeholders, including farmers, government bodies, and exporters, is vital. However, it often falls short due to lack of cohesive strategies and communication gaps".

The issue of capital investment emerged as a significant hurdle, particularly in the context of upgrading existing systems to meet evolving industry standards. A senior logistics executive lamented, "We need substantial investment to streamline operations and integrate new technologies. Without it, progress is stymied".

The discussion also revealed the complexity of design in implementing solutions that are user-friendly and accessible to all stakeholders. An executive from the research and development department highlighted, "Ease of use and awareness are critical for adoption. Any new system must be intuitive and easily navigable to ensure widespread uptake".

Moreover, the interviews shed light on the need for improved collaboration and trust-building measures between FPCs and farmers. A sentiment expressed by multiple participants was the necessity of fostering stronger relationships based on transparency and mutual benefit. "Trust is essential for sustainable partnerships. We need clearer communication and shared accountability," emphasized a warehouse manager.

In summary, the interviews conducted with employees and farmers in the grape trade sector underline multifaceted challenges that inhibit the optimization of agricultural supply chains. While awareness of innovative technologies and sustainable practices is evident, the effective implementation of these solutions remains a formidable task. Issues such as payment reliability, stakeholder engagement, and trust deficits persist, highlighting the urgent need for coordinated efforts to address systemic inefficiencies. Moving forward, collaborative initiatives that prioritize transparency, streamlined processes, and technological advancement will be pivotal in driving meaningful change within the industry.

6. Implications for Theory and Practice:

The insights gained from the interviews in the grape supply chain offer valuable implications for both theoretical advancements and practical applications within agricultural supply chain management.

6.1. Implications for Theory:

- **Technology Integration and Complexity:** The discussion underscores the challenge of integrating advanced technologies like Blockchain into existing agricultural supply chain systems. This highlights the need for theoretical frameworks that address the complexities of technology adoption in practical settings. Future research could focus on developing models that facilitate seamless integration and usability of technologies within supply chain operations.

- **Stakeholder Engagement and Trust:** The interviews emphasize the critical role of stakeholder engagement and trust-building in supply chain management. This calls for theoretical developments that explore the dynamics of trust formation and maintenance among diverse stakeholders. Understanding the mechanisms that foster collaboration and transparency can enhance theoretical insights into effective supply chain governance.
- **Sustainability and Ethical Practices:** The acknowledgment of sustainability targets and ethical considerations within supply chain operations suggests a need for theoretical frameworks that integrate environmental and social dimensions into traditional supply chain models. Research efforts could focus on developing holistic frameworks that balance economic objectives with sustainability imperatives.
- **Operational Efficiency and Design Complexity:** The complexity of design and operational inefficiencies highlighted in the discussions point to the importance of theoretical advancements in supply chain optimization. Future research could delve into innovative methodologies for streamlining operations, enhancing data accuracy, and reducing design complexities in supply chain management.

6.2. Implications for Practice:

- **Technology Implementation Strategies:** Practitioners can leverage the insights from the interviews to develop tailored strategies for implementing technologies like Blockchain. This may involve investing in user-friendly systems, providing training programs, and fostering a culture of innovation within organizations.
- **Enhanced Stakeholder Collaboration:** The emphasis on stakeholder involvement underscores the practical need for collaborative approaches in supply chain management. Practitioners can implement initiatives that promote communication, transparency, and mutual understanding among stakeholders to build sustainable partnerships.
- **Payment System Improvements:** Addressing the issue of delayed payments requires practical interventions such as implementing reliable payment systems and establishing clear contractual agreements. FPCs and farmers can work together to streamline payment processes and ensure timely disbursements.
- **Capacity Building and Investment:** Recognizing the need for capital investment, organizations can prioritize resource allocation towards upgrading infrastructure, adopting new technologies, and enhancing operational capacities. This entails strategic planning and collaboration with relevant stakeholders.
- **User-Centric Design:** To address design complexities and usability challenges, practitioners can prioritize user-centric design principles when developing supply chain systems. Investing in intuitive interfaces, feedback mechanisms, and training programs can enhance user adoption and system effectiveness.

7. Conclusion, limitation, and future research:

In conclusion, the interviews with stakeholders and farmers in the grape trade sector reveal important insights into the challenges and complexities of agricultural supply chain management. The discussions underscore the increasing awareness of innovative practices like Blockchain technology and sustainability goals among industry participants. However, operational hurdles, stakeholder engagement issues, and payment inefficiencies persist as significant barriers to progress. The findings highlight the critical need for collaborative efforts and strategic interventions to address these challenges and drive meaningful improvements within the agricultural supply chain.

Despite the valuable insights gained, certain limitations should be acknowledged. The sample primarily represents stakeholders and farmers within the grape trade sector, potentially limiting the generalizability of findings to broader agricultural contexts. Additionally, the scope of discussions may not fully encompass broader socio-economic or policy-related factors influencing agricultural practices. Further, the subjectivity of responses and potential biases inherent in qualitative research could influence the interpretation of results. Lastly, the temporal context of the interviews may not capture evolving dynamics or emerging trends in supply chain management.

Looking ahead, future research in agricultural supply chain management could delve into exploring alternative governance structures that foster transparency and inclusivity among stakeholders. Longitudinal studies assessing the sustained impact of technology adoption, particularly Blockchain, on supply chain efficiency and sustainability, would be valuable. Additionally, analyzing the role of policy frameworks and regulations in facilitating innovation and collaboration within supply chains could provide actionable insights. Furthermore, investigating cross-sectoral collaborations between agriculture, technology, finance, and policy sectors could unlock new opportunities for transformative change in agricultural supply chain management. Addressing these research avenues will contribute to advancing knowledge and driving positive outcomes in agricultural supply chain practices.

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