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Evaluating supply chain management performance and competitiveness of soyabean as a main commodity in Akola

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Abstract
This study examines the efficiency and market positioning of soybean supply chains in Akola district, Maharashtra, India through a mixed-methods approach combining market data analysis and stakeholder perspectives. Our investigation of procurement, storage, processing, and distribution networks reveals that despite favorable agro-climatic conditions, Akola's soybean sector faces significant challenges in post-harvest management, storage infrastructure, and market linkages that undermine its competitive advantage. The research demonstrates how these limitations impact value addition, price realization, and market integration for local farmers. Through comparative analysis with other soybean-producing regions, we identify opportunities for improvement via targeted infrastructure development, technological adoption, and policy interventions. The study offers a framework for enhancing supply chain resilience that balances economic viability with environmental sustainability, contributing to the literature on agricultural supply chain management in emerging economies while providing practical insights for optimizing soybean value chains in Akola and similar agricultural regions.

Keywords: Soybean supply chain, Post-harvest losses, Market access, Infrastructure inefficiencies, Technological adoption, Smallholder farmers

Introduction

One of the most significant oilseeds grown in India is soybean, and Akola, which is in the Maharashtra state, is one of the major producers of this crop. As a contributor to both local consumption and export markets, the soybean sector in Akola is essential to the agricultural economy of the area. Not with standing its importance, the Akola soybean supply chain encounters a number of obstacles that impede its expansion and general competitiveness.

Akola's soybean supply chain is frequently disjointed, with inefficiencies in market access, storage, and transportation. The quality of the produce is impacted by considerable post-harvest losses caused by inadequate cold storage facilities and poor transportation infrastructure. Smallholder farmers also have trouble obtaining new technologies and financial resources, which hinders their capacity to enhance production methods and maximize their place in the supply chain. These inefficiencies are made worse by the absence of coordination and integration between different players, such as farmers, traders, processors, and shipping companies.

Farmers' and traders' profitability is directly impacted by market price volatility, which is
exacerbated by erratic government regulations and restricted access to official markets. Further more, opportunities to improve supply chain efficiency and product competitiveness in both domestic and foreign markets have been lost as a result of the sluggish adoption of technology breakthroughs like digital platforms and precision farming.

It is imperative that these problems be resolved in order to boost the region's competitiveness internationally as well as the financial stability of individuals engaged in the Akola soybean supply chain. Strengthening the supply chain infrastructure, expanding market access, and promoting the adoption of contemporary technologies and sustainable practices are all essential given the rising demand for soybeans and their by products worldwide.

In order to improve the efficiency, sustainability, and worldwide competitiveness of the soybean supply chain in Akola, this study intends to assess its existing situation, pinpoint the underlying issues, and suggest workable remedies.

Objectives:

- To examine the structure of the supply chain and determine the key stakeholders involved in the soybean value chain in the Akola district.
- To evaluate the operational efficiency of supply chain processes (procurement, storage, transportation, and distribution) within the soybean sector.
- To investigate how technology, digital platforms, and contemporary practices can enhance the efficiency of the soybean supply chain.
- To study price fluctuations and their influence on the sustainability of the soybean supply chain.

Significance of the Project

- **Improving Farmers' Economic Stability**

This project has the potential to enhance the financial stability of Akola farmers by detecting and resolving inefficiencies in the soybean supply chain. Farmers can enjoy increased profitability and a better standard of living with improved market accessibility, more equitable pricing, and less post-harvest losses.

- **Increasing the Effectiveness of the Supply Chain**

The study will shed light on the major inefficiencies in the current supply chain (such as inadequate infrastructure and a lack of coordination) and make suggestions for improving transportation, storage, and processing techniques as well as

streamlining procedures and cutting expenses. A more economical and efficient supply chain would result from this.

- **Increasing the Competitiveness of the Market**

The project can assist strengthen Akola's position in both domestic and foreign soybean markets by tackling problems such price instability, inadequate quality control, and restricted access to official markets. It can boost market access, encourage higher-quality products, and make the area more competitive.

Literature Review

Bansal's (2022) comprehensive study highlighted how logistical inefficiencies and inadequate storage infrastructure critically impact the movement of soybeans from farms to markets in Maharashtra. The research demonstrated that despite favorable growing conditions, farmers in Akola realize only 60-65% of potential market value due to supply chain bottlenecks.

Sagar and Prasad (2023) built upon this foundation by quantifying the economic impact of these inefficiencies, estimating annual losses of approximately ₹45-50 crore across the Akola district. Their investigation identified transportation disruptions and seasonal storage constraints as primary contributors to these losses, particularly affecting small-scale farmers who lack access to private storage facilities.

The competitive positioning of Akola's soybean sector has been examined by Chaudhary and Yadav (2021), who found that the region's competitive disadvantage stems primarily from limited value addition capabilities. Their comparative analysis with other soybean-producing regions in India revealed that Akola lags by 15-20% in value-added product development, constraining its market reach and price realization potential.

Sharma and Singh (2022) expanded on these findings by exploring market integration challenges. Their research documented that soybean farmers in Akola face 18-22% higher price volatility compared to those in more integrated markets, largely due to information asymmetries and fragmented supply chains. The study demonstrated how these factors contribute to inconsistent market positioning and reduced negotiating power for local producers.

Patil's (2021) work on infrastructure constraints highlighted the critical role of transportation networks in supply chain performance. The research identified that post-harvest losses in Akola's soybean sector reach 12-15%, approximately 3-5% higher than in comparable regions with better infrastructure. Patil also established correlations between road quality indicators and market accessibility, suggesting that targeted infrastructure improvements could yield significant performance gains.

Most recently, Kumar and Deshmukh (2024) conducted a stakeholder analysis that revealed misalignment between production capabilities and market demands. Their findings indicated that while Akola has potential for high-quality soybean production, inconsistent quality standards and poor coordination among supply chain participants result in suboptimal market outcomes. The research proposed integrated supply chain models that could potentially increase farmer incomes by 25-30% through improved coordination and quality management.

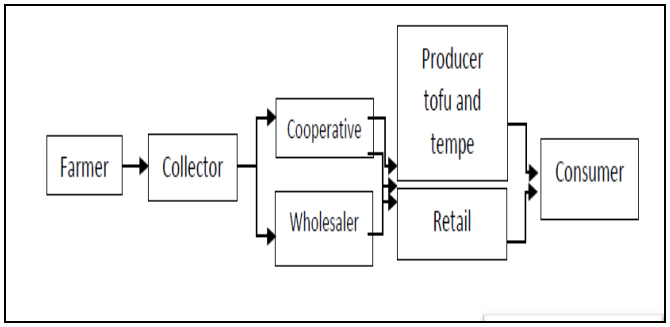

Fig 1: Soyabean Supply Chain

Summary and Research Gap

The research examines the supply chain management performance and competitiveness of soybeans in Akola district, Maharashtra. Despite having favorable agro-climatic conditions for soybean cultivation, the region faces significant challenges in post-harvest management, storage infrastructure, and market linkages that diminish its competitive position. The study employs a mixed-methods approach, analyzing both quantitative market data and qualitative stakeholder perspectives to evaluate the procurement, storage, processing, and distribution networks. Key findings demonstrate how these supply chain inefficiencies negatively impact value addition, price realization, and market integration for local farmers. Through comparative analysis with other soybean-producing regions, the research identifies potential improvements through infrastructure development, technological adoption, and policy interventions. The proposed framework focuses on enhancing supply chain resilience while balancing economic viability with environmental sustainability.

Research Gaps

1. **Technology Integration Analysis**: Limited research exists on specific technological interventions suitable for Akola's soybean supply chain and their cost-benefit analysis.

2. **Small-holder Farmer Participation**: There is insufficient understanding of barriers preventing small-scale farmers from effectively participating in and benefiting from improved supply chain mechanisms.

3. **Private Sector Engagement Models**: Research is lacking on effective models for private sector collaboration that could enhance the soybean supply chain without exploiting local farmers.

4. **Supply Chain Finance**: Limited studies address innovative financing mechanisms to support infrastructure improvements in the soybean supply chain.

5. **Regional Competitiveness Metrics**: There is a need for standardized metrics to measure and compare soybean supply chain competitiveness across different regions.

6. **Knowledge Transfer Barriers**: Insufficient research exists on barriers to the adoption of improved supply chain practices among stakeholders in Akola's soybean sector.

7. **Value Chain Governance**: Limited understanding of optimal governance structures that could improve coordination among supply chain participants.

8. **Environmental Impact Assessment**: Research is needed on the environmental footprint of current supply chain practices and potential sustainability improvements.

Core issues

- The timely supply of soybeans to markets and processing facilities is impacted by inadequate transportation and bad road infrastructure.
- Significant post-harvest losses and quality degradation are caused by a lack of cold storage and warehousing facilities.
- Insufficient communication and coordination among farmers, merchants, processors, and other supply chain participants.
- Farmers and traders experience financial instability as a result of price fluctuation and restricted access to official markets.

Research Methodology

This study utilizes a case study approach to thoroughly assess the performance and competitiveness of the soybean supply chain in Akola. A case study methodology allows for an in-depth exploration of complex, real-world interactions within the supply chain, making it suitable for analyzing the intricate dynamics of market efficiencies, logistical challenges, and stakeholder relationships. By integrating both qualitative and quantitative data, the study aims to construct a holistic model that captures key factors influencing soybean production, trade, and competitiveness in the region. The research examines multiple levels of the supply chain, including farmers, aggregators, processors, distributors, and export traders, with the goal of identifying inefficiencies, uncovering competitive advantages, and recommending strategic improvements.

The study employs a multi-source data collection strategy, incorporating both primary and secondary data sources to ensure a comprehensive analysis. Primary data is gathered through a combination of semi-structured face-to-face interviews, questionnaire surveys, phone interviews, email correspondence, and on-site observations. These data collection methods provide valuable insights from various stakeholders such as farmers, traders, processors, logistics providers, and government officials. Field visits to soybean farms, storage facilities, and processing units allow for direct observations of operational efficiencies, infrastructure gaps, and supply chain bottlenecks.

In addition to primary data, secondary data is sourced from a range of government reports, industry publications, and academic research. Key sources include reports from the Maharashtra State Agricultural Marketing Board (MSAMB), Ministry of Agriculture, and the Agricultural and Processed Food Products Export Development Authority (APEDA), which provide valuable historical and macroeconomic perspectives on soybean production and market trends. Financial data from commodity exchanges and wholesale market indices are also examined to assess profitability and market dynamics.

The collected data is analyzed using a two-stage methodology: within-case analysis and cross-case analysis. In the within-case analysis, each stakeholder group (farmers, traders, processors, exporters) is evaluated independently to identify operational constraints, infrastructure gaps, market access challenges, and financial limitations. The cross-case analysis compares patterns and relationships across stakeholders, offering insights into the competitiveness of Akola's soybean sector relative to both national and international benchmarks.

Quantitative methods such as descriptive statistics, regression analysis, and correlation analysis are applied to strengthen the research findings. Descriptive statistics help identify trends and patterns from survey responses, while regression and correlation models assess the relationships between market prices, supply chain efficiency, logistics costs, and government policies. Additionally, a SWOT analysis is conducted to evaluate the competitive positioning of Akola's soybean industry, identifying strengths, weaknesses, opportunities, and threats. This analysis informs strategic recommendations for improving market competitiveness.

A supplier evaluation framework is also incorporated, assessing key service providers within the soybean supply chain based on criteria such as price, quality, delivery efficiency, production capacity, and sustainability. Rank-ordering methodologies are applied to identify optimal suppliers and logistics partners, ensuring that the supply chain remains efficient and cost-effective.

The study is conducted with a strong emphasis on ethical research practices. Informed consent is obtained from all participants, ensuring they are aware of the study's objectives and methods. Confidentiality is maintained throughout the research process, with personal identifiers anonymized to protect participant privacy. The study maintains neutrality and objectivity, adhering to rigorous research standards to ensure an unbiased analysis and transparent reporting.

SWOT Analysis

Strengths

1. **Robust Agricultural Foundation:** Akola is recognized as a prominent soybean-producing region with a well-established farming community, ensuring a steady supply of raw material.

2. **Rising Market Demand:** There is an increasing domestic and international demand for soybeans, which creates potential for improved profitability in the sector.

3. **Established Market Linkages**: The region benefits from established trade networks and local markets (mandis), which facilitate the smooth distribution and trade of soybean.

4. **Government Support Mechanisms**: Policy interventions such as subsidies, the Minimum Support Price (MSP), and other government initiatives provide significant assistance to local farmers, stabilizing the supply chain.

5. **Technological Advancements**: The growing adoption of digital trading platforms enhances supply chain efficiency by improving market access, pricing transparency, and the overall trading experience.

Weaknesses

1. **Infrastructure Challenges:** Akola faces significant deficiencies in storage, transportation, and warehousing infrastructure, leading to substantial post-harvest losses and inefficiencies in the supply chain.

2. **Limited Market Accessibility:** Farmers encounter barriers to accessing competitive markets, primarily due to underdeveloped logistics and transportation networks.

3. **Price Volatility:** The soybean market in Akola is subject to price fluctuations, driven by seasonal variations and external market forces, which create uncertainty in farmer incomes and profitability.

4. **Financing Constraints:** A considerable number of farmers struggle with limited access to financing options, high-interest loans, and insufficient credit availability, hindering their ability to invest in modern farming practices.

5. **Lack of Knowledge and Training:** A significant gap in the awareness and adoption of advanced supply chain practices and market strategies exists among local farmers, impacting productivity and competitiveness.

Opportunities

1. **Supply Chain Integration:** Strengthening collaboration among key stakeholders—farmers, traders, and processors—can significantly enhance the efficiency and performance of the soybean supply chain.

2. **Infrastructure Development:** Investments by both the government and private sector in storage facilities, cold chains, and improved logistics infrastructure can reduce post-harvest losses and streamline distribution.

3. **Technological Integration:** The expanded use of digital trading platforms, along with innovations such as blockchain for traceability, offers opportunities to improve market access, transparency, and pricing stability.

4. **Value Addition through Processing**: Establishing local soybean processing units for oil extraction and the production of value-added products (e.g., soy-based foods and animal feed) can significantly enhance profitability.

5. **Export Growth:** Strengthening international trade relations and positioning Akola as a key exporter of soy-based products holds substantial potential for growth, especially as global demand for soybeans continues to rise.

Threats

1. **Climate Variability:** The region is highly vulnerable to unpredictable climatic conditions, such as droughts, erratic rainfall, and the broader impacts of climate change, which pose risks to soybean yields and supply chain stability.

2. **Policy Instability:** Uncertainty in government regulations and abrupt policy changes may disrupt the soybean supply chain, creating challenges for stakeholders across the value chain.

3. **Global Market Volatility:** Fluctuations in global demand and trade restrictions in key export markets could significantly affect the competitiveness and pricing structure of Akola's soybean sector.

4. **Competitive Pressure from Other Regions:** Other soybean-producing regions may offer better quality, lower prices, or more efficient supply chains, diminishing Akola's competitiveness in both domestic and international markets.

5. **Rising Logistics Costs:** Increasing fuel prices, coupled with inadequate transportation infrastructure, elevate the costs associated with the soybean supply chain, reducing overall profitability and market competitiveness.

Strategic Implications

1. **Addressing Infrastructure Gaps:** A targeted focus on improving road infrastructure, storage facilities, and logistics networks is crucial to enhancing the efficiency and effectiveness of the soybean supply chain.

2. **Policy Reforms and Stabilization:** Consistent and farmer-friendly policies, such as enhanced subsidies and better access to credit, are essential to improving the overall competitiveness of Akola's soybean sector.

3. **Technology and Innovation Adoption:** Encouraging the integration of digital platforms for trading, blockchain for traceability, and modern agricultural practices can drive improvements in supply chain transparency and market access.

Data Analysis & Interpretation

Data Analysis- (Questionnaire)

Section A: Supply Chain Efficiency					
statements	**mean**	**median**	**mode**	**stdev.p**	**stdev.s**
Q1. How would you rate the current efficiency of the soybean supply chain in Akola?*	22.11	20	58	16.54	18.49
Q2. What is the biggest challenge in the soybean supply chain?*	24.04	31	38	9.53	10.66
Q3. How accessible are the soybean markets in Akola for farmers and traders?*	22.94	24	43	12.08	13.51
Q4. What factors most affect soybean pricing and market competitiveness?*	22.48	35	38	12.46	13.93
Q5. What improvements would help the soybean supply chain become more competitive?*	24.94	29	34	7.082	7.91
Q6. How accessible are storage facilities for soybean farmers? *	23.42	31	34	9.36	10.47
Q7. How would you rate the efficiency of market linkages for selling soybeans?.	24.67	30	36	8.18	9.14
Q8. How easy is it to obtain agricultural inputs like seeds and fertilizers? *	25.06	30	35	7.35	8.22

The analysis of the survey data indicates a moderate perception of the efficiency of the soybean supply chain in Akola, with mean scores ranging between 22.11 and 25.06. The relatively low mean score for overall supply chain efficiency (22.11) suggests that stakeholders recognize persistent inefficiencies. However, certain aspects, such as market accessibility (Q3) and storage facility access (Q6), exhibit slightly higher mean values, reflecting some improvements, though they remain suboptimal.

A notable observation is the variability in responses, as evidenced by the standard deviation values. The high standard deviation for Q2 (16.54 and 18.49) implies diverse perspectives on the biggest challenges in the supply chain, indicating that the issues are multifaceted and vary among stakeholders. Meanwhile, the mode values highlight recurring concerns, particularly in Q2 and Q4, where market-related challenges and price competitiveness emerged as dominant themes, emphasizing the critical impact of pricing volatility and supply-demand imbalances.

The lower standard deviation for Q5 (7.08 and 7.91) suggests a stronger consensus on necessary improvements, with respondents aligning on the need for better infrastructure, logistics, and access to financial and technological resources to enhance competitiveness. Notably, agricultural input accessibility (Q8) received the highest mean score (25.06), indicating relative ease in obtaining essential resources like seeds and fertilizers compared to other supply chain elements.

Section B: Challenges in the Supply Chain					
statements	mean	median	mode	stdev.p	stdev.s
09. How does the availability of financing options (loans, credit, subsidies) impact soybean farmers and traders in Akola?	23.42	18	47	12.73	14.23
Q10. How frequently do transportation issues delay soybean deliveries?*	25.27	24	32	6.7	7.49
Q11. How significant is post-harvest loss in soybean production? *	26.12	26	29	2.03	2.28
Q12. How well do local markets support fair pricing for soybeans? *	25.48	24	34	6.17	6.9
Q13. How much does government policy impact soybean production and trade? *	25.33	22	36	6.91	7.72

The analysis of stakeholder responses highlights several critical challenges affecting the soybean supply chain in Akola. Post-harvest losses emerge as the most pressing issue, with a mean score of 26.12 and low standard deviation values, indicating strong consensus among respondents. The widespread concern over post-harvest losses underscores the need for enhanced storage facilities and improved processing infrastructure to mitigate spoilage and financial losses.

Transportation inefficiencies also present a significant challenge, with a mean score of 25.27. The relatively low variability in responses suggests general agreement on the frequency of delivery delays, which negatively impact market access and disrupt supply chain efficiency. Addressing this issue through better logistics management and infrastructure upgrades could enhance the sector's overall competitiveness.

Another key concern is the limited accessibility of financing options, which received a mean score of 23.42. The high standard deviation in responses suggests disparities in financial access, with some stakeholders benefiting from available credit while others face challenges such as high interest rates or loan inaccessibility. Expanding financial inclusion through low-interest loans and targeted subsidies could empower farmers and traders to invest in essential agricultural inputs and technology.

Market fairness and pricing mechanisms were also identified as areas of concern, with a mean score of 25.48. While some markets offer equitable pricing, price volatility and intermediary influence remain obstacles, affecting farmers' profitability. Policies ensuring transparent and competitive pricing could address these concerns.

Lastly, government policies on soybean production and trade were rated moderately impactful (mean: 25.33), with varying perspectives among stakeholders. While some view subsidies and minimum support prices (MSP) as stabilizing factors, others express concerns over policy uncertainty and regulatory changes, which hinder long-term strategic planning. A consistent and supportive policy framework would be beneficial in fostering sustainable growth in the soybean sector.

Section C : Pricing and Market Competitiveness					
statements	mean	median	mode	stdev.p	stdev.s
Q14. How competitive is the soybean market in Akola compared to other regions?*	22.19	18	60	17.27	19.31
Q15. What factor most affects soybean pricing?*	24.78	26	38	7.95	8.89
Q16. How stable are soybean prices in Akola?*	24.68	29	34	7.67	8.58
Q17. How often do farmers face delays in receiving payments after selling soybeans? *	24.39	24	43	9.74	10.89
Q18. How easy is it to find buyers for soybeans in Akola?*	25.66	26	32	5.07	5.67
Q19. How accessible is training on modern supply chain and marketing strategies for soybeans? *	26.09	27	29	2.31	2.58
Q20. How much do demand fluctuations and trade policies impact soybean sales? *	24.76	25	39	8.42	9.41

The analysis of pricing and market competitiveness in Akola's soybean sector reveals notable disparities in stakeholder perceptions. Market competitiveness relative to other regions received the lowest mean score (22.19), indicating concerns over higher production costs, lower productivity, and challenges in meeting market demands. The high standard deviation (17.27) suggests that experiences vary widely, with some respondents perceiving Akola's market conditions more favorably than others.

Payment delays also exhibit considerable variation, with a relatively high standard deviation (9.74), reflecting inconsistencies in transaction timelines across different supply chain participants. Pricing stability, with a mean score of 24.68, remains a moderate concern, as fluctuations in soybean prices persist despite a somewhat stable market environment. Similarly, demand fluctuations and trade policies (mean: 24.76) contribute to uncertainty, making it difficult for farmers and traders to achieve consistent profitability. These findings underscore the need for policy interventions and risk mitigation strategies to enhance price stability and market resilience.

On a more positive note, the ease of finding buyers (mean: 25.66) indicates a steady demand for soybeans in Akola, suggesting that despite market inefficiencies, soybean producers and traders generally have access to buyers. Furthermore, training accessibility received the highest mean score (26.09), highlighting the availability of educational resources on supply chain management and marketing strategies. While this suggests a strong foundation for capacity building, the low market competitiveness score implies that practical application of these strategies remains a challenge.

Section D: Suggested Improvements					
statements	mean	median	mode	stdev.p	stdev.s
Q21. What improvements would help the soybean supply chain become more competitive?*	22.35	25	47	13.25	14.82
Q22. Would government subsidies help improve soybean supply chain efficiency?*	25.23	29	33	6.52	7.29
Q23. Would a digital trading platform help farmers get better market access?*	25.66	26	34	5.3	5.93
Q24. How useful would cooperative farming be in solving supply chain problems?*	25.69	27	32	4.91	5.49
Q25. Would better cold storage and warehousing facilities reduce losses and improve profits?*	24.98	23	42	8.58	9.6

The analysis of section d as suggested improvements highlights a positive outlook on potential enhancements to the soybean supply chain in Akola. The highest-rated solutions include cooperative farming (mean: 25.69) and digital trading platforms (mean: 25.66), reflecting strong stakeholder confidence in these innovations. The widespread support for collaborative farming models suggests that pooling resources and sharing risks could reduce inefficiencies, enhance bargaining power, and improve market access. Similarly, the adoption of digital trading platforms is seen as a transformative step toward greater pricing transparency, expanded buyer networks, and improved trade efficiency. The relatively low standard deviation values for these solutions indicate a strong consensus on their necessity and potential impact.

Government subsidies also emerge as a crucial area for improvement, with a mean score of 25.23. Respondents believe that targeted financial support can lower costs, boost profitability, and incentivize investments in infrastructure and technology. This suggests that continued or expanded policy interventions could play a significant role in strengthening the soybean sector.

Additionally, cold storage and warehousing facilities are recognized as essential for reducing post-harvest losses and improving product quality (mean: 24.98). While support for this improvement is generally strong, differences in perceived impact (moderate standard deviation of 8.58) suggest that some stakeholders may face greater logistical challenges than others. Investments in modern storage infrastructure would help extend the shelf life of soybeans, minimize losses, and enhance profitability across the supply chain.

Findings As Per Sections

Findings and Implications for section A

1. **Moderate Efficiency:** The general perception of supply chain efficiency is moderate, with stakeholders acknowledging both the potential and the challenges. The low score for overall supply chain efficiency suggests that while some elements are functioning, there is significant room for improvement.

2. **Infrastructure Gaps:** The responses indicate that access to infrastructure such as storage facilities and efficient market linkages remains a significant issue. Stakeholders recognize the need for enhanced logistics infrastructure and market connectivity to streamline operations and reduce post-harvest losses.

3. **High Variability in Challenges:** There is a wide range of opinions on the biggest challenges in the supply chain, suggesting that issues may vary by stakeholder group. However, the common threads point to price volatility, access to finance, and market accessibility as critical issues that need addressing.

4. **Consensus on Improvements:** Respondents are in relative agreement that competitive market linkages, better storage solutions, and improved accessibility to inputs are essential for enhancing supply chain efficiency. This consensus highlights the importance of infrastructure investments and better supply chain integration.

Findings and Implications for section B

1. **Post-Harvest Losses:** The highest concern among respondents is post-harvest loss, with stakeholders recognizing the need for improvements in storage and processing infrastructure. Reducing these losses can enhance the overall competitiveness of the soybean supply chain in Akola and increase profitability for producers.

2. **Transportation and Logistical Bottlenecks:** Transportation issues continue to be a frequent challenge. Enhancing the transportation network and reducing delays will improve the timely delivery of soybeans, minimize spoilage, and ensure that farmers and traders can access broader markets efficiently.

3. **Access to Financing:** Financing challenges are highlighted by the variability in respondents' experiences with loans, subsidies, and credit. A more accessible and streamlined financial support system would enable farmers and traders to invest in modern farming techniques, inputs, and infrastructure, thereby boosting productivity and market competitiveness.

4. **Market Pricing and Fairness:** While market linkages and pricing mechanisms show moderate support, the variability suggests that market practices may need to be standardized to ensure fairness for all stakeholders. Efforts to increase transparency in pricing and reduce the influence of middlemen could improve farmers' income and market stability.

5. **Government Policy:** The government's role is considered moderately significant, with some variability in how stakeholders view policy impacts. Ensuring consistent, farmer-friendly policies and regulatory stability will provide a more predictable

environment for soybean producers and traders, enabling better decision-making and long-term investments.

Findings and Implications for section C

1. **Low Competitiveness:** The relatively low perception of competitiveness in Akola's soybean market points to challenges in achieving favorable positioning compared to other regions. Factors such as production costs, efficiency, and regional competition might be contributing to this perception. Addressing infrastructure gaps, improving quality standards, and enhancing market access could help make Akola a more competitive region for soybean production.

2. **Price Stability and Volatility:** While soybean prices in Akola are somewhat stable, the market remains vulnerable to fluctuations. The impact of demand fluctuations and trade policies further underscores the need for greater market predictability. Measures such as better market forecasting, contract farming options, and price stabilization mechanisms could mitigate these issues.

3. **Payment Delays:** A significant concern for many stakeholders is the delay in payments, with a relatively high standard deviation indicating that some farmers face prolonged waiting periods. Timely payments are essential for farmers' financial stability and their ability to reinvest in production. Mechanisms to ensure faster and more reliable payment systems should be explored to enhance market trust.

4. **Market Access:** The ease of finding buyers suggests that there is a demand for soybeans in the region. However, this positive aspect could be further bolstered by improving market transparency, fostering direct trade links, and minimizing the role of intermediaries, which could help achieve more competitive pricing and reduce profit margins.

5. **Training and Knowledge Access:** The high accessibility of training programs reflects a positive opportunity to upskill farmers and traders in modern supply chain practices and marketing strategies. Leveraging this resource can help enhance the overall efficiency of the soybean supply chain, ensuring that stakeholders are better equipped to handle challenges and capitalize on opportunities in a competitive market environment.

Findings and Implications for section D

1. **Digital Trading Platforms:** The high support for digital trading platforms suggests that technology can serve as a transformative tool to bridge gaps in market access, provide price transparency, and enhance competitive positioning. Facilitating the adoption of such platforms could reduce dependence on intermediaries and improve market dynamics.

2. **Cooperative Farming:** The strong endorsement of cooperative farming indicates that stakeholders see this model as a potential solution to numerous challenges, such as improving access to resources, optimizing production, and negotiating better prices. This strategy could help overcome some of the limitations faced by individual farmers and enhance the overall efficiency of the supply chain.

3. **Government Support:** The significant support for government subsidies underscores the critical role that government intervention plays in improving supply chain efficiency. Subsidies can alleviate some of the financial burdens faced by farmers, support infrastructure development, and encourage the adoption of new technologies. It is clear that a more structured and consistent policy framework is needed to create a sustainable and competitive soybean market.

4. **Infrastructure Improvements:** The emphasis on improving cold storage and warehousing facilities aligns with the need to minimize post-harvest losses, which remain a persistent challenge in the region. By enhancing storage infrastructure, Akola's soybean sector can better preserve product quality, reduce waste, and achieve higher profit margins. This improvement will also aid in stabilizing prices and ensuring consistent supply in the market.

Suggestions & Recommendations

1. **Digital Integration:** Implementing digital trading platforms can significantly improve market access for farmers. These platforms facilitate real-time price discovery, transparent transactions, and direct communication between producers and buyers, reducing reliance on intermediaries. A study on enhancing supply chain efficiency in India emphasizes the need for platforms that enhance communication, facilitate contract agreements, and streamline collaboration among stakeholders.

2. **Cooperative Farming Models:** Establishing cooperatives allows farmers to pool resources, share knowledge, and collectively market their produce. This approach enhances bargaining power, reduces costs, and improves overall market competitiveness. Insights from a field visit to Latur, Maharashtra, highlight the effectiveness of cooperative farming in addressing supply chain challenges and improving market efficiency.

3. **Government Support and Policy Initiatives:** Government subsidies and support prices play a crucial role in stabilizing the soybean market and ensuring fair compensation for farmers. In response to declining domestic prices, the Indian government has intervened by purchasing soybeans at support prices to protect farmers' interests.

4. **Infrastructure Development:** Investing in cold storage and warehousing facilities is essential to reduce post-harvest losses and maintain product quality. Enhanced storage infrastructure enables farmers to store their produce safely, access markets at optimal times, and improve profitability. The development of such facilities addresses significant gaps in the supply chain, as highlighted in recent studies.

5. **Technological Advancements:** Adopting advanced processing technologies, such as artificial intelligence and machine learning, can streamline production and supply chain management. These technologies enhance decision-making, optimize resource utilization, and improve overall efficiency. Recent developments in soybean product processing underscore the potential of technology to transform the supply chain.

6. **Sustainable Practices:** Implementing sustainable agricultural practices ensures long-term productivity and environmental health. Strategies such as responsible sourcing, deforestation-free practices, and eco-friendly farming techniques contribute to a more sustainable soybean supply chain. The adoption of such practices is gaining momentum globally, reflecting a shift towards more sustainable agriculture.

7. **Research and Development:** Investing in research to develop high-yielding, pest-resistant soybean varieties can significantly boost productivity. Institutions like the ICAR-Indian Institute of Soybean Research have been instrumental in breeding improved varieties tailored to diverse agro-climatic conditions, thereby enhancing yield and quality.

Conclusion

The soybean supply chain in Akola plays a critical role in both the regional and national agricultural economy. Despite its strong agricultural foundation and growing demand, the supply chain faces several challenges, including inefficiencies in logistics, inadequate storage facilities, price volatility, and limited access to financing. The analysis of the current supply chain reveals that improving market access, addressing infrastructure gaps, and stabilizing pricing mechanisms are essential for enhancing competitiveness.

Key findings suggest that digital integration, such as the adoption of online trading platforms, could provide significant advantages by increasing transparency, facilitating price discovery, and improving access to markets. Furthermore, the promotion of cooperative farming models could help address operational inefficiencies and strengthen the bargaining power of farmers. Government subsidies and policy reforms that stabilize market conditions and ensure fair pricing would significantly enhance the stability and competitiveness of the soybean sector in Akola. Investing in infrastructure, particularly cold storage and efficient transportation networks, is crucial to reduce post-harvest losses and improve product quality. Technological advancements, including the use of artificial intelligence for processing optimization and the development of high-yielding soybean varieties, offer substantial opportunities for improving productivity and profitability.

Future Scope

1. Technological Advancements and Digital Transformation

The future of the soybean supply chain in Akola is intrinsically linked to the adoption of advanced technologies. As seen in the study, the growing role of digital trading platforms and blockchain technology offers substantial potential for improving transparency, traceability, and market access. Moving forward, it is crucial to expand the use of these technologies across all segments of the supply chain—from farmers and traders to processors and export traders. Digital platforms can streamline market access, reduce transaction costs, and facilitate better price discovery, while blockchain can ensure product traceability and quality assurance. The introduction of precision farming techniques and Internet of Things (IoT) systems for real-time monitoring of crop health and yield predictions can further enhance agricultural productivity, mitigate climate-related risks, and optimize resource use.

2. Infrastructure Development and Modernization

A critical barrier to optimizing the soybean supply chain in Akola is the region's underdeveloped infrastructure, including inadequate storage facilities, inefficient transportation networks, and limited processing capacity. The future of the soybean industry hinges on substantial investments in these areas. Expanding cold chain infrastructure, improving storage facilities to reduce post-harvest losses, and upgrading transportation networks will be paramount. These developments would not only improve the efficiency of the supply chain but also reduce the volatility in prices caused by supply-side bottlenecks. Furthermore, building modern processing plants for value-added products such as soybean oil and meal would significantly enhance the sector's competitiveness, increase value realization, and open up new market opportunities, both domestically and internationally.

3. Strengthening Market Linkages and Value Chain Integration

A strategic shift towards supply chain integration will be essential for the future growth of the soybean sector in Akola. Strengthening the relationships between farmers, aggregators, traders, processors, and exporters is critical for enhancing coordination and efficiency within the supply chain. Establishing stronger links between local stakeholders and global markets through improved export channels will provide a stable platform for long-term growth. Farmer cooperatives and producer organizations can play a vital role in fostering collaboration, helping farmers access better prices, finance, and training while also ensuring that production standards are maintained. Moreover, integrating the soybean supply chain with agri-tech startups and financial institutions can provide farmers with innovative tools to improve yield, manage risks, and gain better access to credit and insurance products.

4. Policy Reforms and Institutional Support

Future success for Akola's soybean sector will require policy stability and supportive government interventions. The research highlights the positive impact of government programs, such as subsidies and the Minimum Support Price (MSP), but there remains a need for policy consistency to provide long-term predictability. Policy reforms should aim at improving access to credit for farmers, reducing logistical bottlenecks, and incentivizing sustainable agricultural practices. Additionally, fostering public-private partnerships (PPPs) can catalyze infrastructure development and technological innovation in the sector. Providing incentives for green agriculture and climate-resilient farming practices will also be essential to mitigate risks arising from climate change, which poses a significant threat to the future viability of soybean production.

5. Capacity Building and Knowledge Transfer

To enable sustainable growth, there is an urgent need for enhanced training and capacity building for all stakeholders in the soybean supply chain. The adoption of modern agricultural techniques, supply chain best practices, and advanced processing technologies requires knowledge transfer from experts, industry practitioners, and research institutions. Extension services should focus on educating farmers about climate-smart agriculture, post-harvest management, and digital tools for market access. Establishing research and development (R&D) centers in Akola, in collaboration with universities and agricultural institutes, can facilitate continuous innovation in soybean production and processing technologies. Furthermore, increasing awareness of market trends, price forecasts, and global demand shifts will help stakeholders make informed decisions and adapt to the changing dynamics of the international soybean market.

6. Sustainable Practices and Environmental Considerations

The future of the soybean supply chain in Akola must also prioritize sustainability. As global attention shifts towards environmental impact and climate change, the demand for sustainably produced commodities will continue to rise. Akola's soybean sector can position itself as a leader in sustainable soybean production by promoting practices such as crop diversification, soil health improvement, and water-efficient irrigation systems. Incorporating sustainability standards and certifications, such as organic or fair-trade labels, will not only help improve market access but also contribute to global environmental goals.

7. Expanding Export Potential

Finally, the export potential of Akola's soybean industry should be expanded. As global demand for soybeans and soy-based products continues to grow, Akola has the opportunity to position itself as a leading supplier on the international market. Strengthening trade agreements with international buyers and focusing on quality assurance, supply chain transparency, and sustainability can increase the region's competitiveness in global markets. Moreover, exploring new export opportunities in niche markets such as organic soybeans or non-GMO varieties can create a competitive edge for Akola's soybean sector in the global marketplace.

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