SCIENTIFIC CULTURE
www.sci-cult.com

SCIENTIFIC CULTURE, Vol. 12, No. 2.1, (2026), pp. 12132-12142
Open Access. Online & Print

DOI: 10.5281/zenodo.20293889

DISTRIBUTION CHANNEL NETWORK IN DAIRY SUPPLY CHAIN MANAGEMENT: EVIDENCE FROM WEST BENGAL, INDIA

Anindita Basu[1*], Pritam Chattopadhyay[2], Abhijit Pandit[3]

[1]Research Scholar, Amity Business School, Amity University Kolkata, India, anindita.basu2016@gmail.com
ORCID ID: https://orcid.org/0009-0002-2027-3041
[2]Associate Professor, Amity Business School, Amity University Kolkata, India,
pchattopadhyay@kol.amity.edu, ORCID ID: https://orcid.org/0000-0002-6836-6055
[3]Associate Professor, Department of Management, Brainware University, Kolkata, India,
abhijitpandit1978@gmail.com, ORCID ID: https://orcid.org/0000-0003-2122-3468

Received: 07/04/2026
Accepted: 08/05/2026

Corresponding Author: Anindita Basu
(anindita.basu2016@gmail.com)

ABSTRACT

Dairy industry in India is one of the most important elements of the agricultural economy, and West Bengal is one of the most important regions of the national milk production. The dairy supply chains involve distribution channel networks that help in the effective movement of milk and dairy products between the producers and consumers without compromising on quality and avoiding losses. The current research paper explores the distribution channel network within dairy supply chain within West Bengal, based on primary data of the farmers, representatives of cooperatives, independent dairy operators, supply chain managers and government officials. The paper combines the findings of comparative case analysis, especially that of Amul in Gujarat, and best practices throughout the globe. The study is based on a mixed-method with the aim of investigating the inefficiencies of cold storage, transportation, and quality control, examining the impact of cooperatives, private enterprises, and technological solutions like AI, IoT, and blockchain. Results indicate that distribution systems in West Bengal are still disjointed and small scale farmers have great difficulties accessing the market. The paper highlights the importance of policy reforms, mutual strengthening, and adoption of technology that would improve efficiency of distribution. This is demonstrated in five analytical tables that show variability in production, level of satisfaction, use of technology, sustainability practices and the performance of the distribution channels. The research ends with the recommendations on how to construct resilient, sustainable and technologically empowered distribution networks in the dairy sector of West Bengal.

KEYWORDS: Distribution Channel Network, Dairy Supply Chain, West Bengal, Cooperatives, Private Enterprises, Cold Chain, Logistics, Technology Adoption, Sustainability.

1. INTRODUCTION

Supply chains cannot operate without distribution channel networks, which decide the flow of products between producers and consumers. The dairy industry, where milk is very perishable, cannot have an effective distribution channel without the need to maintain quality, reduce spoilage and consumer confidence (Patel and Sharma, 2022). The largest milk producer in the world, India has created various models of distribution, including cooperative-based, and network-based models based on the private enterprise (NDDB, 2021). With a tranche of about 5.9 million metric tonnes of milk per annum, West Bengal holds a considerable place in this scene (Kumar & Nambirajan, 2020). Nevertheless, the distribution networks in the state continue to be affected by such issues as poor cold chain infrastructure, logistical inefficiencies, and low involvement of small-scale farmers (Mishra and Shukla, 2022).

The distribution channel of the dairy supply chain in West Bengal is characterized by several steps milk production, collection centers, chilling and processing factories, cooperative and private distribution systems, and retail sales (West Bengal Dairy Federation, 2021). Each phase brings in possible areas of inefficiencies, especially in case the infrastructure is poor or stakeholders lack co-ordination with one another. There are cooperative societies like Benmilk, which have tried to simplify the procurement and distribution process, yet it is still limited compared to that of Amul in Gujarat (Rangasamy, 2020). Modern logistics and marketing strategies have been implemented by such private enterprises as Mother Dairy and Nestle India, but the latter faces significant issues with the high cost of procurement and the unstable demand (Singh et al., 2021).

Distribution channel networks are not only important in logistics. They have a direct impact on the income of farmers, consumer satisfaction, and sustainability of the dairy industry. Poor distribution causes milk to be contaminated, spoilt, and lose consumer credibility (Sharma and Bose, 2021). On the other hand, efficient networks boost traceability, minimize wastes, and maximize profitability (Das et al., 2023). As the urban population grows and people gain knowledge of quality, the dairy industry in West Bengal needs to shift to more technologically-advanced and sustainable distribution systems.

This paper aims at examining the distribution channel network of dairy supply chain West Bengal. The research incorporates primary data of 400 respondents, who belong to various stakeholder groups, and secondary data of government reports and industry publications, which allows gaining an overall picture of prevailing inefficiencies and possible ways of improvement. The comparative experiences of Gujarat and world leaders point to the best practices that can be implemented in the context of West Bengal. The research will not only be of help in the academic community but also in real-world policymaking by providing evidence-based suggestions on enhancing distribution channels in the dairy industry.

2. REVIEW OF LITERATURE

Supply chains cannot operate without distribution channel networks, which decide the flow of products between producers and consumers. The dairy industry, where milk is very perishable, cannot have an effective distribution channel without the need to maintain quality, reduce spoilage and consumer confidence (Patel and Sharma, 2022). The largest milk producer in the world, India has created various models of distribution, including cooperative-based, and network-based models based on the private enterprise (NDDB, 2021). With a tranche of about 5.9 million metric tonnes of milk per annum, West Bengal holds a considerable place in this scene (Kumar & Nambirajan, 2020). Nevertheless, the distribution networks in the state continue to be affected by such issues as poor cold chain infrastructure, logistical inefficiencies, and low involvement of small-scale farmers (Mishra and Shukla, 2022).

The distribution channel of the dairy supply chain in West Bengal is characterized by several steps milk production, collection centers, chilling and processing factories, cooperative and private distribution systems, and retail sales (West Bengal Dairy Federation, 2021). Each phase brings in possible areas of inefficiencies, especially in case the infrastructure is poor or stakeholders lack co-ordination with one another. There are cooperative societies like Benmilk, which have tried to simplify the procurement and distribution process, yet it is still limited compared to that of Amul in Gujarat (Rangasamy, 2020). Modern logistics and marketing strategies have been implemented by such private enterprises as Mother Dairy and Nestle India, but the latter faces significant issues with the high cost of procurement and the unstable demand (Singh et al., 2021).

Distribution channel networks are not only important in logistics. They have a direct impact on the income of farmers, consumer satisfaction, and sustainability of the dairy industry. Poor distribution

causes milk to be contaminated, spoilt, and lose consumer credibility (Sharma and Bose, 2021). On the other hand, efficient networks boost traceability, minimize wastes, and maximize profitability (Das et al., 2023). As the urban population grows and people gain knowledge of quality, the dairy industry in West Bengal needs to shift to more technologically-advanced and sustainable distribution systems.

This paper aims at examining the distribution channel network of dairy supply chain West Bengal. The research incorporates primary data of 400 respondents, who belong to various stakeholder groups, and secondary data of government reports and industry publications, which allows gaining an overall picture of prevailing inefficiencies and possible ways of improvement. The comparative experiences of Gujarat and world leaders point to the best practices that can be implemented in the context of West Bengal. The research will not only be of help in the academic community but also in real-world policymaking by providing evidence-based suggestions on enhancing distribution channels in the dairy industry.

3. RESEARCH GAPS

Although the literature on dairy supply chain management is rich, there is still a need to fill a number of gaps in the knowledge of the distribution channel networks in West Bengal. First, a majority of the research is devoted to the aspects of production and processing, and the nature of the distribution systems is paid little attention (Sharma et al., 2022). Second, cooperative models like Amul have already been widely researched, but limited research on the comparative efficiency of cooperative networks in West Bengal, especially Benmilk, exists to assess their efficiency in distribution (Roy & Banerjee, 2021). Third, the technological advancements like AI, IoT, and blockchain have been mentioned in the international discussions, but there is limited empirical data on their implementation and the effect on the distribution channels in the state of West Bengal (Das et al., 2023). Fourth, distribution sustainability aspects such as green logistics and waste minimization are not well studied in the dairy industry in the state (Rahman and Khan, 2020). Lastly, policy interventions were examined in general, whereas particular inferences to distribution channel networks in West Bengal need more in-depth research (Mitra & Bhattacharya, 2022). These gaps need to be filled by ensuring the construction of resilient and efficient distribution systems capable of promoting the welfare of farmers and consumer satisfaction.

4. RESEARCH OBJECTIVES

The objectives of this study are to:

1. Analyze the current structure of distribution channel networks in West Bengal's dairy supply chain.
2. Identify key challenges affecting distribution efficiency, including cold storage, transportation, and quality control.
3. Examine the role of cooperatives and private enterprises in shaping distribution networks.
4. Evaluate the impact of technological innovations on distribution performance.
5. Assess the sustainability of distribution practices in the dairy sector.
6. Propose policy recommendations for strengthening distribution channel networks in West Bengal.

5. RESEARCH QUESTIONS AND HYPOTHESES

The study is guided by the following research questions:

- How efficient are the current distribution channel networks in West Bengal compared to national benchmarks?
- What are the primary logistical and infrastructural challenges affecting distribution efficiency?
- How do cooperatives and private enterprises differ in their distribution strategies and outcomes?
- What role do technological innovations play in improving distribution networks?
- How do sustainability practices influence distribution efficiency and profitability?
- What policy interventions are necessary to strengthen distribution networks in West Bengal?

Based on these questions, the following hypotheses are formulated:

H1: Distribution channel networks in West Bengal are less efficient compared to national benchmarks.

H2: Logistical constraints, such as inadequate cold storage and transportation inefficiencies, negatively impact distribution efficiency.

H3: Cooperative distribution networks provide greater efficiency compared to private enterprises.

H4: Technological innovations (AI, IoT, Blockchain) significantly improve distribution performance.

H5: Sustainable distribution practices enhance long-term profitability and environmental conservation.

H6: Policy reforms and government interventions positively impact distribution efficiency.

H7: Small-scale farmers face greater barriers in accessing efficient distribution networks compared to large-scale producers.

6. METHODOLOGY

This study will be a mixed-method one, using both quantitative and qualitative data. Structured questionnaires, interviews, and focus group discussions were used to gather primary data and interviewed 400 respondents (farmers, cooperative representatives, private dairy operators, supply chain managers, and government officials). The stratified random sampling guaranteed representation of various groups of stakeholders and geographical areas in West Bengal. Secondary data were obtained from government reports, industry publications, and academic research on dairy supply chains.

Quantitative analysis was done using descriptive statistics, regression analysis, ANOVA, and chi-square tests to determine relationships between distribution efficiency, technology adoption, sustainability practices, and policy support. The qualitative analysis was based on thematic coding of the responses to interview questions to reflect the stakeholder views on distribution issues and opportunities. The comparative study based on the Amul model in Gujarat and the international best practices gave further information about possible interventions in West Bengal. The combination of primary and secondary data, coupled with strong statistical tools makes the findings reliable as well as generalizable. The methodology, therefore, offers an elaborate approach to the distribution channels network analysis of the dairy supply channel in West Bengal.

7. ANALYSIS

Distribution channel networks of the dairy supply chain in West Bengal are analysed using both primary and secondary data. The 400 respondents sample offers an understanding of milk production, contentment with supply chain, technology adoption, and sustainability practices. Descriptive statistics, regression analysis, ANOVA, and chi-square tests were used as statistical tools to test the relationships between variables. The findings are further contextualized in comparison to the Amul model of Gujarat and the best practices across the globe.

7.1. Distribution of Satisfaction Levels

There are differing levels of satisfaction of the current distribution channel network among the stakeholders. The level of satisfaction among farmers and cooperative representatives is low in comparison with that of private dairy operators, as there are differences in the access to infrastructure and markets. The histogram analysis indicates a fairly equal distribution, with moderate satisfaction the majority. This signifies that although certain changes have been identified, there is still a lot of inefficiency.

Table 1: Satisfaction Levels Across Stakeholder Groups.

Occupation	Mean Satisfaction	Std Dev	Minimum	Maximum
Farmers	2.4	1.2	1	5
Cooperative Representatives	2.7	1.3	1	5
Private Dairy Operators	3.6	1.1	1	5
Supply Chain Managers	3.0	1.4	1	5
Government Officials	2.9	1.2	1	5

This table presents the fact that private dairy operators are comparatively more satisfied, probably because of having access to improved technology and logistics. The farmers and representatives of cooperatives, nevertheless, are not satisfied, which is manifested in the form of infrastructural and financial limitations (Sharma and Bose, 2021).

7.2. Milk Production Variability

The daily number of milk produced in occupations differs greatly. The median production is reported to be higher when it comes to cooperative representatives and private dairy operators as compared to farmers and government officials. This gap underscores the imbalanced distribution of resources and infrastructures between the stakeholders. The presence of outliers in the data set means that there are people who are very high in the data set and there are those who are at subsistence levels.

This inconsistency of production highlights the plight of small-scale farmers, who do not have access to modern technology and cooperative assistance. The hypothesis that the private enterprise helps in

modernization is supported by the fact that the production level by the private operators is high due to their better infrastructure (Singh et al., 2021).

Table 2: Milk Production per Day Across Occupations.

Occupation	Median Production (Litres)	IQR (Litres)	Minimum	Maximum
Farmers	210	120	10	479
Cooperative Representatives	280	150	25	460
Private Dairy Operators	335	160	20	499
Supply Chain Managers	270	140	15	498
Government Officials	250	130	42	499

7.3. Technology Adoption in Distribution

Adoption of technology is not even among stakeholders. Compared to the rates of adoption of AI, IoT and blockchain by private dairy operators and supply chain managers, farmers and cooperative representatives are lagging. This gap impacts efficiency of distribution, with technologically facilitated networks being in better position to manage cold chain monitoring, demand forecasting, and traceability.

Table 3: Technology Adoption Across Stakeholder Groups.

Occupation	Mean Adoption Score (1-5)	Std Dev	Minimum	Maximum
Farmers	2.1	1.0	1	5
Cooperative Representatives	2.4	1.1	1	5
Private Dairy Operators	3.8	1.2	1	5
Supply Chain Managers	3.5	1.3	1	5
Government Officials	2.9	1.2	1	5

The use of technology in distribution, as this table confirms, is associated with higher performance of distribution, which confirms the hypothesis that innovations contribute greatly to efficiency improvement (Das et al., 2023).

7.4. Sustainability Practices in Distribution

In West Bengal the sustainability practices in the distribution networks are still minimal. Though the green logistics and waste reduction strategies have been embraced by some cooperatives and private enterprises, small-scale farmers are not in a position to adopt these strategies due to lack of resources. The positive correlation between the sustainability practices and profitability is a good sign that eco-friendly practices can enhance efficiency in the long-run.

Table 4: Sustainability Practices and Profitability.

Sustainability Measure	Adoption Rate (%)	Profitability Correlation	Impact Level
Green Logistics (low emissions)	32	0.41	Moderate
Waste Reduction (biogas/fertilizer)	27	0.35	Moderate
Ethical Sourcing/Animal Welfare	18	0.22	Low
Cold Chain Efficiency	40	0.48	High

This table indicates that the cold chain efficiency is associated with profitability the most, which supports the significance of infrastructure investment (Rahman and Khan, 2020; Yadav and Sharma, 2022).

7.5. Distribution Channel Performance

Cooperatives, private enterprises and unorganized sectors have different performance in distribution channels. Cooperatives are more efficient in milk collection and participation of farmers whereas the private enterprises are more efficient in the application of technology and modernization. The unstructured sector is still disorganized, having bad infrastructure and access to the market.

Table 5: Distribution Channel Performance Across Enterprise Types.

Enterprise Type	Collection Efficiency	Technology Adoption	Farmer Participation	Market Reach
Cooperatives	High	Moderate	High	Moderate
Private Enterprises	Moderate	High	Moderate	High
Unorganized Sector	Low	Low	Low	Low

The following table shows the advantages and disadvantages of various types of enterprises. Cooperatives are essential in the welfare of the farmers, whereas modernization is propagated by private enterprises. The unstructured sector needs a lot of policy intervention to enhance efficiency (Kurien, 2018; Rangasamy, 2020).

8. FINDINGS

The findings show some significant results. To support H1, first, the distribution channel networks in West Bengal are not as efficient as they are at the national level. H2 is correct since logistical constraints, such as the lack of cold storage, and the lack of transportation efficiency, adversely affect distribution efficiency. H3 is supported by cooperative networks which offer greater satisfaction levels and greater participation by the farmers. However, H6 is strengthened by the fact that the adoption and modernization is first of all taken by private enterprises. Adoption of technology enhances the performance of distribution greatly which confirms H4. Sustainability practices, especially cold chain efficiency, strengthen profitability which justifies H5. H6 is correct as policy interventions have a positive effect on the efficiency of distribution. Lastly, small-scale farmers have more obstacles to the access to efficient distribution networks than large-scale producers, which supports H7.

The results in this study show a multi-layered image of channel network distribution of dairy in West Bengal dairy chain. The initial big discovery is that the distribution networks within the state are not as efficient as the ones in the whole country. Although India as an entire country has established organized systems in form of cooperative systems like Amul, West Bengal still suffers with disjointed networks, poor infrastructure and intermittent policy support. The level of satisfaction reported by the stakeholders in West Bengal is considerably less than the level of satisfaction reported in the state with more developed cooperative structure. This auger the hypothesis that the lack of efficiencies in the distribution channels is a key restricting factor to the dairy sector of the state attaining its full potential.

The other key finding is the effect of the logistical constraint on the efficiency of distribution. Poor infrastructure such as cold storage facilities and transportation continue to be a challenge. Spoilage of milk was often mentioned by the respondents as a result of lack of refrigeration and time lags in transportation as a result of lack of road connectivity. These logistical problems not only raise costs, but also decrease consumer trust in the quality of dairy products. The chi-square test also established that availability of cold storage is highly related to quality control results and therefore a need to invest in infrastructure. The results indicate that, unless these logistical constraints are tackled, any advances made in other aspects of the supply chain will be of limited effect.

Cooperatives proved to be an important distribution efficiency factor. Members of the cooperative were more satisfied than other members, who were related to private enterprises or the unorganized sector. Cooperatives offer organized collection schemes, consistent pricing systems, and increased involvement of farmers. Nonetheless, they have fewer technological uptakes and weaker governance frameworks that make it impossible to realize the scale and efficiency observed in the Amul model in Gujarat. The results show that enhanced cooperation governance, the adoption of digital payment systems, and the increase in farmer education programs may considerably enhance distribution results in West Bengal.

Instead, the role of the contribution to modernization and development of distribution infrastructure was found to be significant by the private enterprises. The rate of adoption of technologies such as AI-based demand forecasting, IoT-enabled cold chains monitoring, and blockchain-based traceability were higher among respondents in the category of private enterprises. These inventions have enhanced efficiency and minimization of wastage, yet there are still challenges associated with procurement costs and changing demand in the hands of the private enterprises. The results indicate that although the role of the modernization by the private enterprises is important, its effects are constrained by the fluctuation of the market and the

expensive cost of operation.

Technology adoption was another key finding of the study. Those respondents who said that they used technological innovations in their operations were more satisfied and had higher distribution outcomes. The AI-driven demand forecasting was used to optimize the inventory, IoT sensors were used to address correct cold chain management, and blockchain enhanced traceability. Nevertheless, the adoption is not even with small-scale farmers and cooperative representatives trailing behind the private enterprises and supply chain managers. This difference causes inefficiencies in the general distribution channel, as technologically advanced business is not able to cover the inefficiencies of less advanced stakeholders at all. The results highlight the importance of targeted interventions to facilitate the technological inclusion of small-scale farmers and cooperatives.

Profitability was also found to be positively correlated with sustainability practices. The cold chain efficiency was found to have the greatest effect on profitability, followed by green logistics strategies and waste reduction strategies. The ethical sourcing and animal welfare practices, although significant with regard to brand reputation, were not as strongly correlated with profitability. These results indicate that sustainability practices are not only useful to the environment, but also help in achieving long-term efficiency and competitiveness. The adoption of sustainability practices is however low in West Bengal, with majority of the respondents reporting low adoption. This shows the importance of more awareness, training and policy reinforcement to promote sustainable practices in distribution networks.

It was observed that policy interventions are important in determining the outcomes of distribution. Those respondents who said that they were receiving government assistance were more efficient in their operations. Programs like National Diary Plan and Dairy Entrepreneurship Development Scheme have even offered financial and technical assistance yet there are gaps in implementation. The results indicate that the reforms in the policy should be implemented to strengthen the infrastructure, facilitate the use of technology, and assist the small-scale farmers. The collaborations between the government and the business sector might be especially efficient in terms of overcoming the shortage of infrastructures and establishing the distribution networks that will be resistant to the disasters.

The research also found that there were huge differences between the small-scale farmers and large-scale producers. Small farmers claimed that they produced less, had little cold storage, and little use of technology. These impediments deny them the opportunity to be fully integrated in efficient distribution networks and they end up relying on unstructured markets with ineffective infrastructure and volatile prices. Largescale producers, on the other hand, have access to better resources, infrastructure and access to markets. The results validate the fact that small-scale farmers are more disadvantaged to access efficient distribution networks and thus the need to intervene specifically to help them to be integrated into more organized frameworks.

Lastly, the comparative analysis to the Gujarat Amul model and world best practice revealed the significance of collaborative governance, technological innovations, and sustainability. The experience of Amul proves that systems of cooperation that are organized, combined with the introduction of technologies and training farmers, can contribute greatly to the efficiency of distribution. The world best practices also highlight the importance of sustainability and innovation in developing competitive supply chains. The results indicate that the redesign of these practices to fit West Bengal setting has the potential to redesign its distribution networks and enhance efficiency, profitability, and welfare of farmers.

To sum up, the results of this paper are very convincing in terms of the hypotheses regarding the inefficiencies in distribution networks, logistical issues, cooperatives and private enterprises, technological implementation, sustainability and policy intervention. These findings indicate the disorganized character of distribution networks in West Bengal and the necessity of the joint approach that incorporates cooperative empowerment, technological encompassment, sustainability measures, and policy changes. By resolving these issues, West Bengal has the potential to establish strong and effective distribution channels that can improve the livelihoods of farmers, consumer satisfaction, and add to the dairy economy of India.

9. DISCUSSION

The results highlight the disjointedness of the distribution channel networks in the dairy industry in West Bengal. Although cooperatives are critical to the wellbeing of the farmers, they are not efficient because of the lack of technological use. The private businesses are involved in modernization but are faced by high costs of procurement and

unpredictable demand. The unstructured sector is also an important issue, and there is a lack of adequate infrastructure and access to the market.

Distribution efficiency can be improved with the help of technological innovations like AI, IoT, and blockchain as they promise the solution. Demand forecasting through AI has the potential to minimize wastage, cold chain monitoring through IoT-enabled sensors, and traceability through blockchain. Nevertheless, the adoption is not even, with small-scale farmers trailing behind.

Long-term efficiency requires sustainability practices. Strategies aimed at reducing waste, cold chain efficiency, and green logistics not only positively influence the environment but also work on the profitability. The interventions that should be implemented by the policy should ensure that infrastructural strength is enhanced, technology adoption is encouraged and the small-scale farmers are supported. Resilient and sustainable distribution networks could be supported by the involvement of public-private partnerships.

The Amul model of Gujarat provides some comparative insights to emphasize the role of cooperative governance, digital payment systems, and farmer education. Their implementation to fit the context of West Bengal can boost the efficiency of distribution to a large extent. The issue of technology and sustainability in creating competitive dairy supply chains is also highlighted in global best practices.

10. CONCLUSION

An analysis of the distribution channel networks within the dairy supply chain of West Bengal has shown that the chain is a very crucial and at the same time a vulnerable system. Although the state plays an important role in milk production in India, its distribution channels are still disjointed and almost inefficient in comparison to national standards. Farmers and representatives of cooperatives are less satisfied because of poor infrastructure, high transportation costs, and poor access to technology. The challenges of the procurement costs and variable demand are experienced in private enterprises, which is more advanced in regards to logistics and modernization.

Ai, IoT, and blockchain are all technological innovations that offer transformative opportunities in enhancing distribution efficiency. Nonetheless, there is still an uneven adoption as the small-scale farmers fall behind. Cold chain efficiency and sustainability in place of profitability are strongly correlated with sustainability practices, which emphasizes the role of environmentally friendly logistics. Infrastructure investment, education of farmers, and public-private collaborations are policy interventions that are needed to enhance the distribution networks.

The lessons learned by the Amul model of Gujarat reveal the significance of cooperative governance, digital payment mechanisms, and farmer-centric strategies. These practices can be adapted to the West Bengal context to achieve a considerable amount of efficiency in distribution. The international best practices also underscore the importance of technology and sustainability in developing competitive dairy supply networks.

The distribution channel networks in West Bengal need an inclusive approach that incorporates the use of technology, reinforcement of cooperation, sustainability measures and reforms in the policies. The state has an opportunity to construct strong and effective distribution networks that can lead to the improvement of the lives of small-scale farmers, consumer satisfaction, and add to the dairy economy in India by resolving the logistical shortcomings and empowering the small-scale farmers.

The analysis of the networks of distribution channels in the dairy supply chain in West Bengal shows that the system is not only indispensable to the rural economy of the state but also limited due to the perennial lack of efficiency. The data collected using primary and comparative data show that West Bengal is a highly productive state in terms of total milk production in India, but its distribution channels are still in a disorganized state, poorly developed, and not as effective as those at the national level. This waste occurs in various forms: logistical bottlenecks, lack of well-developed cold chain infrastructure, high transportation costs, and unequal technology accessibility. All these issues are detrimental to the capacity of the dairy industry in the state to provide uniform quality, minimize waste, and provide fair participation of farmers.

Among the key findings is the fact that West Bengal distribution networks are extremely reliant upon small-scale farmers, who are the keystone of the industry yet experience a disproportionate difficulty in accessing effective channels. They are exposed to market vagaries and manipulation by middlemen due to their small scale of production, absence of cold storage facilities and exposure to technological advancements. The dairy sector of the state will still face the challenge of inefficiency and inequity without specific interventions aimed at placing small-scale farmers into the organized distribution systems. It is thus important to empower

these farmers by mobilizing them into cooperatives, providing them with financial incentives, and training in order to develop inclusive and resilient distribution networks.

Cooperatives role comes out as a strength and weakness. Cooperatives like Benmilk have been able to offer organized procurement and distribution mechanisms, providing farmers with consistent pricing and bargaining leverage. Nevertheless, the cooperatives in West Bengal are not as large, well-governed, and technologically advanced as Amul in Gujarat to change distribution networks. The answer here is obvious, enhancing cooperative governance, launching digital payment systems, and increasing farmer education programs are major milestones towards duplicating the success of Amul in West Bengal. Cooperatives need to transform into technologically empowered, farmer-based institutions with the ability to handle complicated distribution systems.

Although they play a major role in the modernization, the private enterprises have their share of problems. They have embraced the best technologies like AI, IoT, and blockchain to enhance efficiencies and minimize wastages, yet their effectiveness is curtailed by the high purchasing prices and the variability of demand. It is concluded that merely the intervention of the private enterprises will not be sufficient to overcome the systemic inefficiencies of the dairy distribution in West Bengal. Rather, they have to work together with cooperatives and government agencies in developing integrated networks that integrate modernization and inclusivity. Public-private partnerships provide a bright avenue on which the capabilities of the enterprises and the fact that the small-scale farmers should not be left out of the spoils of modernization is achievable.

The other important conclusion of this study is technology adoption. The facts indicate that enterprises and managers who are open to technological innovations tend to be more satisfied and get better distribution results. The transformative tools that can revolutionize the distribution networks include AI-assisted demand forecasting, cold chain monitoring with IoTs, and blockchain-enhanced traceability. Nevertheless, the adoption is still not even, and small-scale farmers and cooperatives are lagging behind. The conclusion here is that there is a need to carry out specific interventions and make technological inclusion effective, so that the innovations are not limited to individual ventures but are available to all stakeholders. This demands government subsidies, training and initiatives by cooperatives to democratize the use of technology throughout the distribution channel.

The sustainability practices, which are not much in West Bengal, show good correlations with profitability and efficiency. The cold chain, green logistics and waste reduction policies are not only beneficial to the environment but also enhance long term competitiveness. It is concluded that sustainability should be incorporated in the distribution networks as a fundamental principle, not as an optional practice. The enterprises and policy makers should focus more on investing in environmentally friendly infrastructure and cooperatives should encourage awareness and training to the farmers. With the integration of sustainability into distribution systems, West Bengal is able to develop a system that is both economically sustainable and environmentally friendly.

Transforming distribution networks would not be possible without policy interventions. This is demonstrated by the fact that those respondents who obtained government assistance indicated that their operations were more efficient. The National Dairy Plan and the Dairy Entrepreneurship Development Scheme have been of great help but there has been a loophole in their implementation. The summary is that the policy changes should not only be financial aid but also infrastructural investment, simplification of regulations and education of the farmers. The government should promote the idea of public-private partnerships to overcome the infrastructural shortage, and cooperative governance should be supported with the help of policy. West Bengal can only develop robust distribution channels that can compete at national and international levels through elaborate and prolonged policy interventions.

These conclusions are supported by comparative experience of Amul in Gujarat and best practices of the world. The success of Amul indicates that cooperative systems can be structured, which together with technological innovation and education of farmers can change the distribution networks. International best practices also underline the significance of sustainability and innovation towards developing competitive supply chains. It concludes that West Bengal needs to localize these lessons to its local reality, strike a balance between modernization and inclusion, sustainability and profitability. In this way, the state will be able to eliminate the existing inefficiencies and create resilient and competitive distribution networks.

The findings of the given research indicate the disintegrated state of the dairy distribution network

in West Bengal and the necessity to implement the reforms on a large scale. The fortification of cooperatives, technological inclusion, incorporation of sustainability, and sound policy interventions are critical measures that will lead to the development of effective and robust distribution systems. Empowerment of small-scale farmers, development of a public-private alliance and adopting a working model like Amul will help West Bengal to change its dairy industry. The end finding is that distribution channel networks are not simply logistical systems but socio-economic lifelines that define the welfare of farmers, satisfaction of consumers and viability of dairy industry. Through tackling existing inefficiencies and innovation, West Bengal could develop distribution systems to improve livelihoods, food security, and play a major role in the dairy economy of India.

REFERENCES

Babcock, B. (2019). Global dairy industry trends and supply chain challenges. *Journal of Agricultural Economics, 71*(3), 412–428.

Bag, S., Rahman, M. S., & Khan, A. (2021). Sustainability in dairy supply chains: An empirical study. *International Journal of Supply Chain Management, 10*(2), 55–68.

Bose, R., & Sinha, P. (2021). Artificial intelligence in dairy supply chain optimization. *Journal of Operations Research, 68*(4), 233–245.

Chandra, R., & Bose, S. (2019). Transportation costs and inefficiencies in Indian dairy supply chains. *Logistics Review, 12*(1), 77–94.

Chattopadhyay, S. (2020). Cooperative governance and resilience in dairy supply chains. *Indian Journal of Cooperative Studies, 15*(2), 101–118.

Chatterjee, A., & Roy, S. (2022). Digital payment systems and farmer education in dairy cooperatives. *Agricultural Finance Review, 82*(3), 289–307.

Das, P., Ghosh, R., & Sen, A. (2023). Blockchain and IoT in dairy supply chain traceability. *Technology and Innovation Journal, 14*(2), 145–162.

Ghosh, T. (2022). Transportation and logistics challenges in West Bengal's dairy sector. *Journal of Rural Development, 39*(1), 65–82.

Gupta, A., Singh, R., & Verma, P. (2020). Cold storage infrastructure in dairy supply chains. *International Journal of Food Logistics, 9*(3), 201–219.

Kapoor, R. (2021). Ethical sourcing and animal welfare in dairy supply chains. *Journal of Sustainable Agriculture, 13*(4), 312–328.

Kumar, S., & Nambirajan, T. (2020). Dairy farming and rural economy in West Bengal. *Agricultural Economics Review, 28*(2), 145–162.

Kumar, S., Verma, R., & Singh, P. (2022). Adulteration and quality control in Indian dairy supply chains. *Food Safety Journal, 19*(3), 233–249.

Kurien, V. (2018). The Amul model: Cooperative success in India's dairy sector. *Indian Cooperative Review, 56*(1), 12–25.

Mishra, R. (2020). Regulatory constraints in dairy supply chain development. *Policy Studies Journal, 48*(2), 199–214.

Mishra, R., & Banerjee, S. (2021). Cold chain deficiencies in West Bengal's dairy sector. *Journal of Food Logistics, 11*(2), 87–104.

Mishra, R., & Shukla, P. (2022). Supply chain inefficiencies in West Bengal's dairy industry. *Indian Journal of Supply Chain Management, 17*(1), 45–63.

Ministry of Agriculture. (2021). National Dairy Plan and Dairy Entrepreneurship Development Scheme. Government of India.

Mitra, S., & Bhattacharya, R. (2022). Policy frameworks for dairy supply chain efficiency. *Agricultural Policy Review, 14*(3), 178–195.

Mukherjee, A., & Bhattacharya, S. (2021). Technology adoption in Indian dairy supply chains. *Journal of Technological Innovation, 9*(1), 55–72.

NDDB. (2021). Annual report on milk production in India. National Dairy Development Board.

Omore, A., & Baker, D. (2020). Global dairy supply chain management: Challenges and opportunities. *World Dairy Journal, 15*(2), 98–115.

Patel, R. (2021). Policy limitations in structured dairy supply chains. *Indian Policy Journal, 12*(4), 201–219.

Patel, R., & Goyal, S. (2021). Logistics in perishable supply chains: The case of dairy. *Journal of Logistics Studies,*

13(2), 145–162.
Patel, R., & Sharma, P. (2022). Efficiency in dairy distribution networks. *International Journal of Supply Chain Research, 18*(1), 33–49.
Patel, R., Singh, A., & Mehta, K. (2022). Blockchain for traceability in dairy supply chains. *Technology and Society Journal, 11*(3), 201–219.
Prakash, A., & Jain, R. (2022). IoT-enabled cold chain monitoring in dairy logistics. *Journal of Smart Systems, 7*(2), 89–104.
Rahman, M., & Khan, A. (2020). Green logistics in dairy supply chains. *Environmental Economics Review, 15*(1), 77–92.
Rangasamy, K. (2020). Cooperative models in Indian dairy supply chains. *Indian Cooperative Journal, 18*(3), 145–163.
Roy, S., & Banerjee, A. (2021). Cooperative inefficiencies in West Bengal's dairy sector. *Journal of Cooperative Studies, 22*(1), 55–72.
Roy, S., Sen, A., & Ghosh, R. (2021). Sustainability practices in dairy supply chains. *Journal of Sustainable Business, 19*(2), 145–167.
Sharma, P., & Bose, R. (2021). Milk adulteration and consumer confidence in India. *Food Quality Journal, 12*(3), 201–219.
Sharma, P., & Patel, R. (2021). Cooperative structures and efficiency in dairy supply chains. *Indian Journal of Cooperative Economics, 16*(2), 145–163.
Sharma, P., Singh, R., & Verma, P. (2022). Supply chain inefficiencies in Indian dairy industry. *Journal of Agricultural Supply Chains, 14*(1), 55–72.
Singh, R., & Mehta, P. (2022). Blockchain adoption in Indian dairy logistics. *Journal of Emerging Technologies, 8*(2), 145–163.
Singh, R., Verma, P., & Bose, S. (2021). Private enterprises in dairy supply chains. *Business Logistics Review, 19*(3), 201–219.
West Bengal Dairy Federation. (2021). Annual report on Benmilk cooperative operations. Government of West Bengal.
Yadav, R., & Sharma, P. (2022). Waste reduction strategies in dairy supply chains. *Journal of Environmental Management, 17*(2), 145–163.