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Performance Assessment of Indian Dairy Cooperatives: Data Envelopment Analysis Approach

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Abstract
This study aims to analyze the financial growth and technical efficiency of selected dairy cooperatives in India from 2013-14 to 2021-22, utilizing Data Envelopment Analysis (DEA) and Compound Annual Growth Rate (CAGR) methodologies. The Indian dairy sector has witnessed significant growth, with cooperatives playing a vital role in supporting small-scale farmers through collective ownership and equitable profit-sharing. The analysis highlights marked disparities in performance across different geographical zones, revealing that while some cooperative dairies, such as Jammu & Kashmir, Goa, and Sabar, have maintained high levels of technical efficiency (TE) over the years, while others, like Indore and Amritsar, face challenges in operational performance but have room for improvement. The results highlight the essential role of cooperative models in empowering small-scale farmers and improving rural livelihoods, especially in areas with robust cooperative infrastructures such as Gujarat and Karnataka. Similarly, the impressive CAGR of cooperatives in the northern and western regions, respectively, indicates effective operational strategies and investment in infrastructure.
Nonetheless, challenges remain, particularly in the East, where cooperatives are underdeveloped and less efficient. Therefore, focused investments and supportive policies are vital to strengthening these cooperatives, helping them stay competitive and foster growth in the Indian dairy sector. The findings emphasize the importance of enhancing cooperative structures and infrastructure, particularly in underperforming regions, to ensure sustainable growth and competitiveness in the global dairy market. This research provides valuable insights for policymakers and cooperative managers aiming to optimize their operations and reinforce India's leadership in the global dairy market while ensuring sustainable growth and strengthening the socio-economic conditions of millions of rural dairy farmers in India.

Keywords: Indian Dairy, Cooperatives, CAGR, Technical Efficiency (TE), Data Envelopment Analysis (DEA), Financial Growth, etc.

Introduction

The Indian dairy sector is a cornerstone of the national economy, playing a pivotal role in both rural livelihoods and food security. Between 2012 and 2022, the industry experienced considerable growth, with India emerging as the world's largest milk producer. Cooperatives and private dairies are the dominant organizational models in the sector, responsible for much of the production, processing, and distribution of dairy products. (Dairy and Products Annual, 2022). In 2022, global milk production reached approximately 971 million tons, with India contributing a significant 241.2 million tons, growing at a rate of 4.7%. Despite inflationary pressures and a modest per capita milk consumption increase of just 0.8%, the sector demonstrated resilience through steady production growth and improvements in efficiency (Statista.com).

The success of India's dairy sector can be attributed to various government initiatives aimed at enhancing livestock productivity. From 2013-14 to 2021-22, milk production surged from 137.69 million tonnes to 221.06 million tonnes, with annual growth rates rising from 3.97% to 5.29% (Department of animal husbandry and dairying, 2022-2023). Rajasthan and Uttar Pradesh have been depicted as the leading milk-producing states in India in 2022 (Statista.com). States like Karnataka, Gujarat, Rajasthan, and Bihar saw the highest growth rates, reflecting regional advancements in

dairy farming techniques. However, challenges such as rising feed costs and a global decline in milk prices posed significant hurdles, particularly for small-scale farmers who struggle with affordability issues. (USDA-dairy world trade markets and trade-2023).

As India's dairy sector evolves, further emphasis on improving cooperative structures and supporting smallholder farmers will be crucial to maintaining the sector's growth and ensuring long-term sustainability. (Dairy and Products Annual, 2022). With livestock accounting for over 30% of the Gross Value of Output from Agriculture (GVOA), the dairy sector remains underfunded, receiving only 5.6% of the budget in recent years. Yet, the sector's potential to uplift rural incomes is undeniable. (Gulati, 2022).

Indian Cooperative Dairies

India's dairy cooperatives, especially large entities like Amul, continue to be instrumental in supporting rural economies. By consolidating smaller farms and increasing milk yields, cooperatives have helped drive greater efficiency across the sector. Despite these advances, the sector faces ongoing challenges, including fluctuations in global commodity prices and climatic disruptions, such as the erratic monsoon seasons that impact fodder availability. Greater investment, both in terms of financial resources and policy support, could further strengthen the cooperatives, ensuring they remain key drivers of efficiency and productivity within India's dairy industry. (Research & Markets, Food Industry Review, IMARC, 2023).

The success of Indian dairy cooperatives has been a cornerstone in transforming the dairy industry, with the Anand model, epitomized by Amul and the Gujarat Cooperative Milk Marketing Federation (GCMMF), leading the way. This model emphasized collective ownership, democratic management, and profit-sharing, empowering small-scale dairy farmers. By pooling resources and distributing profits equitably, these cooperatives have enabled farmers to access modern dairy practices, veterinary care, and financial services. (Sudan, 2019). This collaborative structure not only increased productivity but also ensured fair returns for farmers, significantly improving their livelihoods.

A key factor in the efficiency of Indian dairy cooperatives has been strategic investments in processing, packaging, and distribution infrastructure. Modern facilities and a well- developed cold chain have allowed fresh milk and dairy products to reach consumers quickly and in good condition, enhancing market reach and profitability. Regional variations in the performance of dairy cooperatives are evident, with the North and West regions leading in dairy societies, milk procurement, and marketing. The West, driven largely by Gujarat, has emerged as a powerhouse, particularly in processing capacity. (NDDB, Annual Report, 2021-22). The robust infrastructure in regions like the West and South, including dairy plants, chilling centers, and bulk milk coolers, has further strengthened the operations of dairy cooperatives. Gujarat and Karnataka, in particular, stand out for their strong contributions to dairy plant capacities. However, the East region lags in infrastructure development, signaling the need for further investment to unlock its potential. This regional disparity highlights opportunities for focused efforts to boost dairy capacity across India.

To bolster this growth, significant financial support has been allocated by the National Dairy Development Board (NDDB), including ₹150 million to enhance marketing capabilities in 2021-22. Additionally, initiatives like "Dairying through Cooperatives" and loans from international agencies have further enhanced infrastructure, modernizing operations and increasing efficiency (NDDB, Annual Report, 2021-22). These efforts are aimed at ensuring that Indian dairy cooperatives remain competitive on a global scale.

Literature Review

(Sutar, Arrawatia, Dhalmahapatra, Garg, & Kumar, 2023) They developed a comprehensive tool for evaluating the performance of Dairy Cooperative Societies (DCSs) in India using the Analytical Hierarchy Process (AHP). Their research revealed that governance and management are key factors contributing to the success of cooperatives. The study emphasizes the importance of structured governance and strategic decision- making in ensuring the long-term sustainability of these dairy cooperatives. Similarly, (Shah, 2020) They highlighted the significance of the "Anand Pattern" cooperative model, which has been instrumental in the success of Gujarat's dairy cooperatives like AMUL. The research underscored that effective governance and strong support mechanisms are critical in driving the efficiency and success of cooperative dairies.

(Mahida, et al., 2018) Focused on the technical efficiency of cooperative members versus nonmembers in Gujarat, cooperative members were found to be generally more efficient. Utilizing Data Envelopment Analysis, the study showed that cooperative membership significantly enhances farmers' efficiency, indicating that there is still room to optimize output with existing resources and technology. These findings align with the broader trend that cooperatives play a key role in enhancing the productivity and livelihoods of small- scale farmers in the dairy sector. (Goel & Awasthi, 2021) We explored how labor shortages during the COVID-19 pandemic impacted the supply chain of cooperative dairies. The research developed an equilibrium supply chain model incorporating labor shortage and risk factors to increase profitability. The findings highlighted the significant impact of labor shortages on supply chain efficiency and the need for strategies to mitigate these risks in future disruptions.

(Alli, Chauhan, Franco, & Singh, 2020) evaluated the efficiency of resource utilization in a cooperative dairy plant with a capacity of 50,000 liters per day (LPD) and emphasized the importance of optimizing resource utilization to enhance efficiency and reduce costs in dairy manufacturing. (Rautela, Sharma, & Bhardwaj, 2017) Examined the distribution logistics of a state-owned dairy in Varanasi, distributing around 10,000 liters of milk daily through hired vehicles to its

retailers. Using the LINGO platform, the study reformulated the vehicle routing problem, reducing the number of routes from seven to four clusters, thereby significantly lowering distribution costs and enhancing the dairy's competitive advantage. (Popker & Raju, 2015) Proposed a straightforward framework for measuring the efficiency of 20 primary dairy cooperative societies from South Goa Dairy as samples and utilized the Data Envelopment Analysis (DEA) model. It incorporated multiple inputs and outputs to determine relative efficiencies, and results indicated that 13 out of the 20 dairy cooperatives were efficient.

(Wani, 2013) Assessed stakeholders' perceptions of constraints in milk production within Jammu and Kashmir Cooperative structures. Additionally, middlemen emerged as a critical barrier within the cooperative system, exacerbating the existing inefficiencies in milk procurement. (Bardhan & Sharma, 2012) They investigated the determinants and implications of smallholder participation in dairy cooperatives, focusing on milk collection and technical efficiency. Their analysis revealed that cooperative membership improved technical efficiency in plains regions but had a negative impact in hilly areas. Moreover, nonmember farmers were found to receive higher prices, indicating inefficiencies in the cooperative structures of certain geographic locations.

(Shah & Sharma, 2012) We identified that adopting effective logistics operating and planning systems is crucial for maintaining flexibility and gaining a sustainable competitive advantage in cooperative dairies. (Singh, Coelli, & Fleming, 2001) Aimed to compare the operational efficiency and overall performance of dairy plants operating under the cooperative and private sectors in India. Utilizing a range of performance metrics, the study employed quantitative analysis to assess factors such as cost efficiency, productivity, and profitability across different dairy plants. The findings revealed significant differences in performance between the two sectors, with cooperative dairy plants typically demonstrating higher levels of efficiency and better alignment with the broader socio- economic goals of the dairy industry in India. The study concluded that cooperative plants play a crucial role in supporting small-scale farmers and contributing to rural development.

Research Methodology

The research methodology employed in this study is designed to thoroughly examine the financial growth and technical efficiency of selected dairy cooperatives in India. Dairy cooperatives serve both financial and social purposes, requiring them to perform efficiently to provide sustainable benefits to their members. This study is significant for policymakers, economists, and managers as it offers insights into enhancing the socio-economic conditions of small farmers while ensuring sustainable benefits for cooperative members. By gathering data on costs, net returns, and efficient asset use, the study aims to contribute to the broader understanding of the cooperative dairy sector in India, which is critical for rural development and income generation.

Research Objective:

As the industry continues to evolve, understanding the financial and technical efficiencies of these cooperatives will be crucial. The main objective of this study is to analyze the financial growth and technical efficiency of selected dairy cooperatives, and it aims to offer insights into optimizing their operations. The ultimate goal is to reinforce India's leadership in the global dairy market while ensuring sustainable growth for millions of dairy farmers across the country.

Research Design:

The research focuses on nine years, from 2013-14 to 2021-22. This period was chosen because, starting from 2013-14, companies in India began preparing their financial accounts under the Companies Act of 2013, which aligns with International Financial Reporting Standards (IFRS) and Indian Accounting Standards (IndAS). The study employs a convenience sampling technique, engaging with authorities from the National Dairy Development Board (NDDB) and district cooperative dairies to collect relevant data. Ten cooperative dairies from various states were selected based on the availability of annual reports and financial data. These dairies represent different regions of India, offering a comprehensive view of the cooperative sector's performance across the country.

The study utilizes Data Envelopment Analysis (DEA) to assess the efficiency of the selected dairy cooperatives. DEA is a non-parametric technique that helps evaluate how efficiently each dairy is converting inputs, such as expenses, fixed assets, and current assets, into outputs like sales. An input-oriented approach is used, focusing on minimizing inputs while maintaining the same level of output. The DEA solver in Excel is employed to calculate the efficiency score for each dairy by comparing them to a reference set of efficient peers (Cooper, Seiford, & Tone, 2007). Efficiency scores range from 0 (indicating inefficiency) to 1 (indicating full efficiency), providing a clear picture of which dairies are performing well and which need improvement.

The study also incorporates the Compound Annual Growth Rate (CAGR) to measure the financial growth of the selected dairies over the study period. CAGR is used to calculate the growth of key financial metrics such as sales, expenses, share capital, fixed assets, and current assets. The formula used is:

$$\text{CAGR} = (\text{Ending Value} / \text{Beginning Value})^{1/\text{Number of Years}} - 1$$

This metric smooths out fluctuations across the nine years, providing a consistent measure of growth that allows for comparison across time and among different dairy cooperatives. The combination of DEA and CAGR offers a robust framework for evaluating both the efficiency and financial growth of the cooperative dairies.

The selected cooperative dairies come from diverse regions, including ten states of India from varied geographical regions. The state cooperatives' dairy units are named Jammu & Kashmir Milk Producers' Cooperative Limited (Jammu

& Kashmir), West Assam Milk Producer's Cooperative Union Limited WAMUL (Assam), Goa State Cooperative Milk Producers Union Limited (Goa), The Amritsar District Cooperative Milk Producers Union Limited (Punjab), Malabar Palakkad district Cooperative Milk Producers Union Limited MILMA (Kerala), Indore Sahkari Dugdh Sangh Maryadit (Madhya Pradesh), Deshratna Dr. Rajendra prasad Dugdh Utpadak Sahkari Sangh Limited Barauni (Bihar), Mysore District cooperative Milk producers' Societies Union Limited (Karnataka), Kolhapur Zilla Sahakari Dugdh Utpadak Sangh Limited (Maharashtra) and Sabarkantha District cooperative Milk producer Union Limited (Gujarat). Each of these dairies plays a vital role in supporting rural economies and providing secondary income for small-scale farmers. The cooperative model prioritizes the welfare of rural communities, often focusing on offering higher milk prices to farmers rather than maximizing profits. Despite criticism about the efficiency of cooperatives, this study demonstrates their crucial role in creating jobs, supporting rural women, and contributing to the socio-economic development of their regions.

In conclusion, this research aims to provide valuable insights into the operational performance of dairy cooperatives in India, highlighting both their financial growth and technical efficiency. The findings will be useful for improving cooperative management strategies, ensuring sustainable income for small farmers, and guiding policymakers in fostering the growth of the dairy sector. Through this comprehensive analysis, the study contributes to the broader understanding of how cooperatives can support rural economies while remaining competitive in the growing global dairy market.

Results and Discussion Compound Annual Growth Rate:

Table 1 CAGR of Selected Cooperative Dairies from 2013-14 to 2021-22

S. No.	Dairy	Total Sales	Total Expenses	Share Capital	Fixed Assets	Current Assets
1	J&K Dairy	38.9%	39.4%	0.0%	21.4%	63.6%
2	WAMUL	13.8%	13.3%	0.1%	25.5%	11.6%
3	Goa Dairy	-0.4%	-0.3%	6.3%	-9.9%	9.3%
4	Amritsar Dairy	11.2%	11.2%	9.5%	39.6%	12.5%
5	MILMA Palakkad	12.0%	10.1%	9.0%	18.6%	15.6%
6	Indore Dairy	7.0%	6.0%	8.3%	7.7%	9.6%
7	Barauni Dairy	2.4%	-14.2%	4.4%	-1.6%	17.3%
8	Mysore Dairy	5.4%	5.7%	5.3%	19.0%	2.3%
9	Kolhapur Dairy	9.7%	9.7%	5.6%	16.4%	11.0%
10	Sabar Dairy	13.8%	14.6%	18.8%	11.9%	18.3%

(Source: Author's Calculations)

Cooperative dairies in Table 1 generally highlight the consistent growth in compound annual growth rate (CAGR) from 2013-14 to 2021-22, showcasing significant disparities in performance. J&K Dairy leads with an impressive 38.9% CAGR in total sales while also experiencing a substantial 63.6% growth in current assets, indicating strong operational liquidity. In contrast, Goa Dairy displays a concerning trend with a slight negative CAGR of -0.4% in total sales despite a notable 6.3% increase in share capital. Other dairies like WAMUL and MILMA Palakkad show steady growth, with total sales CAGR of 13.8% and 12.0%, respectively. Notably, WAMUL has a solid increase in fixed assets at 25.5%, underscoring investment in infrastructure.

Conversely, Barauni Dairy faces challenges, reporting a drastic -14.2% CAGR in total expenses, suggesting potential inefficiencies. Overall, these figures reveal varying growth trajectories and financial health across cooperative dairies, reflecting both opportunities and challenges in the sector. (Umamageshwari, Dixit, & Sivaram, 2016) contrast has shown a less increased average milk sales by a CAGR of 3.54 percent from 2002 to 2013, but there was a significant increase in growth milk product sales by cooperatives (CAGR
= 16%) from 2008 to 2013. The later study concluded that cooperative dairies are strategically focusing on emerging segments to increase sales by offering a wider range of dairy products.

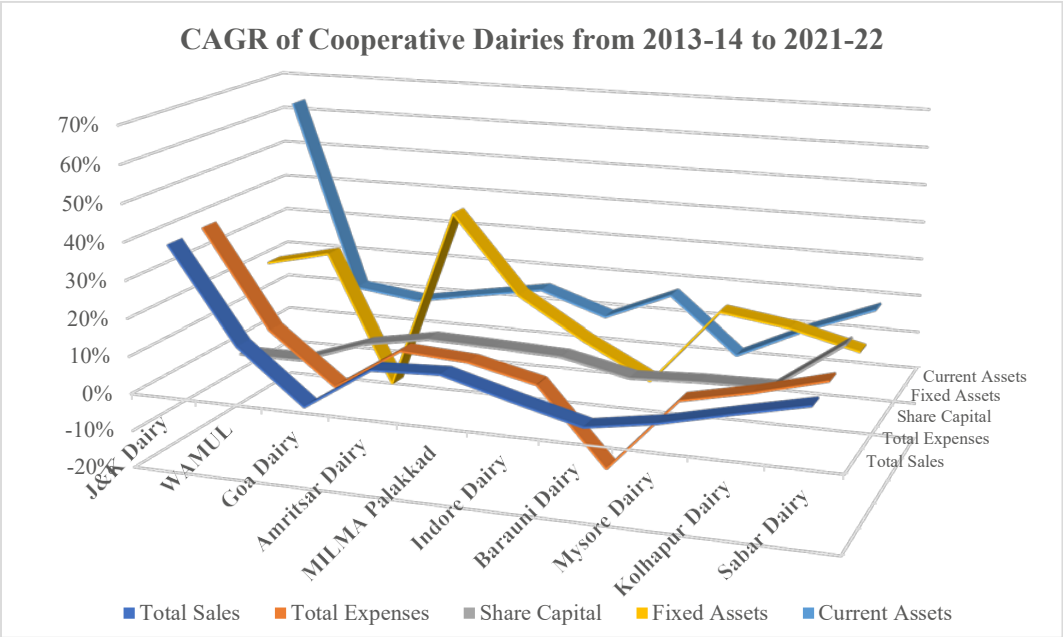

Figure 1: CAGR of Cooperative Dairies from 2012-13 to 2021-22

Cooperative dairies generally benefit from stable expansion. Jammu & Kashmir, WAMUL, and Sabarkantha also show higher CAGR in expenses (39.4%, 13.3% and 14.6%) over eight years as cooperative dairies. In terms of share capital, cooperative dairies have a steady increase, particularly Sabarkantha (18.8% CAGR). In comparing fixed assets, cooperatives like Amritsar (39.6%) and Mysore (19.0%) have shown strong growth. In contrast, a few cooperatives, such as Goa and Barauni (-9.9% and -1.6%), saw a decline in their assets, indicating volatility. In terms of current assets, cooperatives like Jammu & Kashmir (63.6%) and Sabarkantha (18.3%) have exhibited considerable growth and depict a balanced financial performance (Figure 1).

The impressive growth of J&K and Amritsar Dairy, with a CAGR of 38.9% and 11.2% in total sales, highlights the potential of cooperatives in the northern region to empower local farmers and enhance livelihoods. Meanwhile, Sabar, Kolhapur and MILMA Palakkad demonstrate stable growth in the western and southern zones, respectively, indicating effective operational strategies and investment in infrastructure. Overall, while many cooperatives show promise, a strategic focus on enhancing infrastructure and operational efficiency, particularly in underperforming regions, is essential for sustaining growth in the Indian dairy sector and ensuring the long-term viability of small-scale farmers.

Data Envelopment Analysis:

The analysis in the study has been conducted as a single-period DEA. This study has chosen a period of DEA analysis in order to provide a clear picture of the DEA model. When DEA is conducted for each year in the sample period of 9 years, each dairy's yearly efficiency score is obtained. The changing position in terms of efficiency must be noticed to understand better how companies in the sample respond to market-wide factors on a year-on-year basis. A dairy is deemed technically efficient if its score equals 1, meaning it is operating on the efficient frontier. A score of less than 1 indicates inefficiency, implying that the dairy could potentially reduce its inputs while maintaining the same level of sales. The DEA results for cooperative dairies over the period from 2013-14 to 2021-22 presented in Table 2 highlight the efficiency performance of each unit in terms of their ability to convert inputs (expenses, fixed assets, and current assets) into outputs (sales).

Table 2 Technical Efficiency of Selected Cooperative from 2013-14 to 2021-22

S. No.	Dairy	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
1	J&K Dairy	1	1	1	1	1	1	1	1	0.67
2	WAMUL	0.94	0.99	1	1	0.95	1	1	1	0.71
3	Goa Dairy	1	1	1	1	1	1	1	1	1
4	Amritsar Dairy	0.95	0.92	0.97	0.95	0.75	0.97	0.73	0.70	0.67
5	MILMA Palakkad	1	1	1	1	1	0.93	0.89	0.86	1
6	Indore Dairy	0.90	0.99	0.96	0.85	0.75	0.92	0.63	0.76	0.86
7	Barauni Dairy	1	1	1	1	1	1	1	1	1
8	Mysore Dairy	0.99	0.96	0.97	0.98	0.86	0.98	0.90	0.84	0.88
9	Kolhapur Dairy	1	1	1	1	0.99	1	0.94	0.96	0.95
10	Sabar Dairy	1	1	1	1	1	1	1	1	1

(Source: Author's Calculations)

Among several cooperative dairies, J&K Dairy, Goa Dairy, Barauni Dairy and Sabar Dairy maintained consistent efficiency across the years, achieving a score of 1 in almost all the periods and operated effectively, utilizing their resources optimally to generate revenue. J&K Dairy, which maintained perfect technical efficiency until 2021, experienced a notable decline to 0.67, indicating potential challenges in sustaining productivity levels in recent years. In contrast, Amritsar Dairy and Indore Dairy showed a gradual decline in efficiency with dips in performance during certain years, emphasizing the importance of continuous improvement and adaptation in resource utilization to maintain competitiveness. WAMUL exhibited strong efficiency, with fluctuations but ultimately falling to 0.71, suggesting a need for a renewed focus on operational strategies. Conversely, Goa Dairy demonstrated consistent technical efficiency of 1 throughout the period, indicating operational stability. Other dairies, such as Barauni and Sabar Dairies, consistently achieved a perfect efficiency score, reflecting best practices that could serve as benchmarks for underperforming cooperatives. Notably, Kolhapur Dairy maintained a high level of efficiency but with slight reductions in more recent years. The data shows critical need for targeted interventions and strategic investments to enhance technical efficiency, particularly in cooperatives facing challenges, and reinforcing operational sustainability of India's dairy sector.

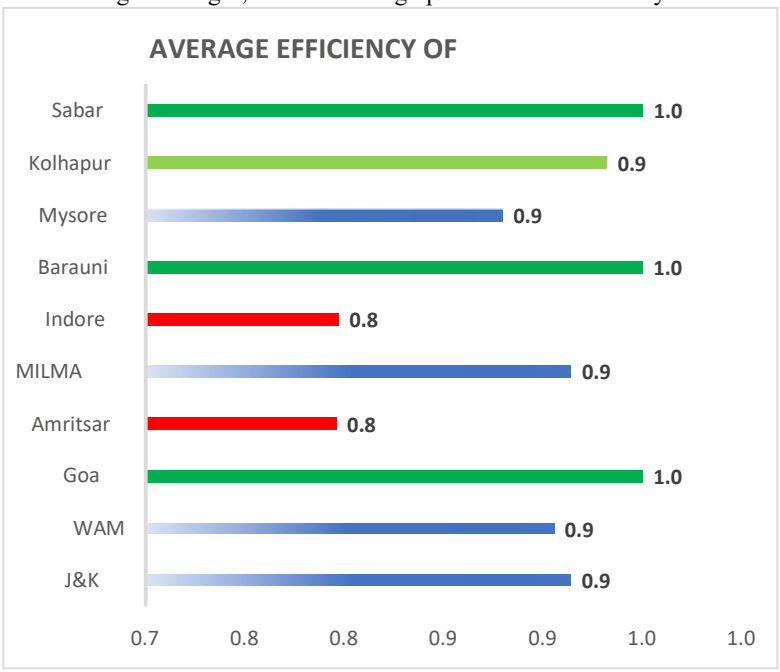

Figure 2: Technical Efficiency of Cooperative Dairies

Figure 2 presents the average technical efficiency (TE) for various cooperative dairies over nine years. Goa Dairy, Barauni Dairy, and Sabar Dairy all have a TE of 1.00, followed by Kolhapur Dairy with a TE of 0.98, which indicates that these dairies operate at full efficiency, making the most of their resources. These dairies are benchmarks in terms of maximizing output with the given inputs, showing strong operational management. Notably, while Goa Dairy is not recognized for its best results in financial growth, it demonstrates strong resource utilization, as reflected in its perfect technical efficiency score.

J&K Dairy, WAMUL, and MILMA Palakkad have identical TE values of 0.96, followed by Mysore Dairy with a TE of 0.93. These dairies are highly efficient but have slight room for improvement to reach the perfect efficiency benchmark. Indore Dairy and Amritsar Dairy have the lowest TE values among cooperatives, both at 0.85. These dairies exhibit significant inefficiencies compared to others, suggesting that they have substantial room for operational improvements, which also helps them get better returns, as we have seen their poor performance earlier.

Conclusion

The Indian dairy sector has seen substantial growth, particularly from 2012 to 2022, and plays a crucial role in the country's economy. Within this sector, both cooperative and private dairies have emerged as key players in the production, processing, and distribution of dairy products. The cooperatives have provided a framework for small-scale farmers to succeed, promoting collective ownership, democratic management, and equitable profit- sharing. In conclusion, this study reveals a nuanced picture of the performance of dairy cooperatives across India's four geographical zones—North, South, East, and West. The analysis using Data Envelopment Analysis (DEA) and Compound Annual Growth Rate (CAGR) highlights significant disparities in financial growth and technical efficiency among the selected dairies. While J&K Dairy and Goa Dairy stand out for their impressive sales growth and operational efficiency, others like Indore and Amritsar show notable room for improvement. The findings underscore the critical role that cooperative models play in empowering small-scale farmers and enhancing rural livelihoods, particularly in regions with strong cooperative infrastructure like Gujarat, Maharashtra and Karnataka. The impressive CAGR of J&K and

Amritsar Dairy in total sales highlights the potential of cooperatives in the northern region to empower local farmers and enhance livelihoods.

Meanwhile, Sabar, Kolhapur and MILMA Palakkad demonstrate stable growth in the western and southern zones, respectively, indicating effective operational strategies and investment in infrastructure. However, challenges persist, especially in the East, where cooperatives lag in development and efficiency. Overall, targeted investments and policy support are essential to bolster these cooperatives, ensuring they remain competitive and continue to drive growth in the Indian dairy sector. By optimizing operations and addressing regional disparities, India can enhance its position as a global leader in dairy production while fostering sustainable rural development.

Recommendations

Cooperative dairies, especially those like Indore and Amritsar, which have lower efficiency scores, should focus on improving operational practices. Streamlining processes and optimizing resource usage can help boost performance.

Cooperative dairies should continue investing in technological innovations and infrastructure to enhance production capacity and efficiency, thereby strengthening their market presence.

Dairy units showing stagnation or negative growth in assets or capital should reevaluate their financial strategies to focus on long-term stability. Cooperative dairies like Goa can significantly benefit from revising their capital investment strategies.

By addressing these areas, cooperative dairies can work toward enhancing their efficiency, financial performance, and overall competitiveness in the dairy sector.

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