

ISSN: 2582-7219



International Journal of Multidisciplinary Research in Science, Engineering and Technology

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.206

Volume 8, Issue 4, April 2025

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206 | ESTD Year: 2018 |



International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET) (A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Evaluating the Growth and Performance of India's Dairy Industry

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ABSTRACT: The dairy industry plays a crucial role in India's agrarian economy, contributing significantly to employment, rural livelihoods, and nutritional security. As the single largest agricultural commodity, the dairy sector contributes approximately 5 percent to India's national economy and provides direct employment to over eight core farmers. India holds a prominent position in the global dairy industry, ranking first in milk production, and accounting for 25 percent of the world's total milk output. This study evaluates the growth and performance of India's dairy sector by analyzing key aspects, such as production trends, market dynamics, policy interventions, and technological advancements. It examines the impact of major initiatives, including Operation Flood, the National Dairy Plan, and digital innovations in the dairy supply chain, on driving the sector's expansion. Despite India's dominance in global milk production, the milk production sector faces several challenges, including productivity gaps, supply chain inefficiencies, and climate change. Addressing these issues is crucial for ensuring the long-term sustainability and efficiency of dairy production. This study provides policy recommendations aimed at enhancing the sector's performance, improving productivity, and ensuring sustainability in the face of emerging challenges.

KEYWORDS: Dairy industry, India, milk production, policy, technological advancements

I. INTRODUCTION

India remains the world's largest producer and consumer of milk, and the dairy industry plays a crucial role in food security and rural economy (Ohlan, 2016). The sector has undergone significant transformations in recent years driven by rising demand, policy interventions, and technological advancements. Evaluating the growth and performance of India's dairy industry requires in-depth analysis of production trends, supply chain efficiency, technological adoption, and financial indicators. The dairy industry is one of the most vital sectors of the Indian economy, contributing approximately 5% of the national GDP and nearly 26% of the agricultural GDP. India produces over 220 million metric tons of milk annually (as of 2023), with the sector growing at a compound annual growth rate (CAGR) of 6% over the past decade. The industry provides a primary source of income for over 80 million rural households, particularly for small and marginal farmers, and employs more than 70 million women, making it a key driver of women's empowerment in rural areas. India contributes approximately 24% of global milk production, with major milkproducing states including Uttar Pradesh, Rajasthan, Gujarat, Madhya Pradesh, and Andhra Pradesh. The share of dairy products in food baskets has increased among both rural and urban consumers, yet regional disparities in production and per capita milk availability persist (Ohlan, 2016). The industry produces a wide range of dairy products, including liquid milk, butter, cheese, yogurt, ghee, ice cream, and milk powders, with value-added products, such as flavored milk, probiotic drinks, and dairy products. India also exports dairy products, such as skimmed milk powder, casein, and ghee, to countries such as Bangladesh, the UAE, and the USA, with the government focusing on improving quality standards to expand in global markets. The White Revolution, spearheaded by Operation Flood in the 1970s, transformed India from a milk-deficient nation into the world's largest milk producer. The Amul model, pioneered by Dr. Verghese Kurien, is a successful example of dairy cooperatives, empowering farmers and ensuring fair prices for milk. To further strengthen the sector, the government has introduced several schemes, including the National Dairy Plan (NDP) to increase milk productivity and improve breed quality, the Rashtriya Gokul Mission to conserve and genetically improve indigenous cattle breeds, and the Dairy Processing and Infrastructure Development Fund (DIDF) to support the modernization of dairy processing plants and the development of cold chain infrastructure. Additionally, there is a growing emphasis on organic and A2 milk production to cater to health conscious consumers. Despite its success, the Indian dairy industry faces several challenges, including low productivity per animal, inefficiencies in cold supply chain management (Kashyap et al., 2023), fragmented supply chains, and the need to meet quality and safety standards in domestic and international markets. To address these challenges and assess industry performance, researchers have employed various methodologies such as key performance indicator analysis (Mor et al., 2018), cost



efficiency measurement using stochastic frontier analysis and data envelopment analysis (Singh et al., 2001), and forecasting models such as ARIMA to predict production trends (Kashyap et al., 2023). The adoption of Industry 4.0 technologies, termed Dairy 4.0, is emerging as a transformative force in the sector (Hassoun et al., 2023). Digital advancements in milk testing, automated dairy farming, and smart cold storage solutions are expected to enhance the efficiency and sustainability in the coming years.

II. LITERATURE REVIEW

2.1 Production and Consumption Patterns

India is the world's largest producer and consumer of milk, with a significant increase in the share of dairy products in both rural and urban food baskets (Ohlan 2016). Demand for dairy products is highly elastic and closely related to income levels. However, regional disparities persist in milk production and per capita availability across states (Ohlan, 2016). Global dairy consumption is projected to increase by 19% per person by 2050, raising concerns about energy consumption and greenhouse gas emissions (Shine et al., 2020).

2.2 Supply Chain Management and Performance

The Indian dairy supply chain is facing various challenges and opportunities. Key performance indicators (KPIs) have been identified to assess and improve supply chain performance, including effective information technology, brand management, shipment responsiveness, accuracy, and control over waste (Mor et al., 2018). Other crucial factors include traceability systems, cold-chain infrastructure, quality management, and technological innovations (Mor et al., 2018). Food safety, product quality, and economic benefits remain major concerns in the dairy supply chain. These issues can be addressed through technological advancements, reducing uncertainty, and implementing global supply chain management practices (Mor et al., 2018). For instance, the Kenyan dairy sector faces challenges in terms of supply chain robustness, institutional governance reliability, and innovation system resilience (Rademaker et al., 2016), but opportunities exist for transitioning towards a more competitive, market-oriented dairy sector that attracts investments.

2.3 Sustainability and Environmental Concerns

The dairy industry's contribution to global food security is significant, but it also raises serious environmental concerns owing to its polluting nature on a large scale (Feil et al., 2020). Sustainability indicators in the dairy industry are emerging but remain in their early stages. This industry faces challenges related to wastewater treatment, energy consumption, and industrial plant efficiency (Feil et al., 2020). Green supply chain management (GSCM) has been identified as an effective strategy to enhance sustainability, productivity, and efficiency in the dairy sector (Sharma et al., 2015). A study in the Indian dairy industry ranked key performance indicators for GSCM implementation using factor analysis and the Analytic Hierarchy Process (AHP) method (Sharma et al., 2015). Dairy farming also contributes significantly to greenhouse gas emissions (Segerkvist et al., 2020). A systematic review of sustainability literature revealed that only 11 of 35 studies addressed all three dimensions of sustainability (environmental, economic, and social), highlighting the need for more comprehensive research (Arvidsson Segerkvist et al., 2020). Pasture-based dairy systems have been found to reduce energy requirements by 35% compared with confinement systems, suggesting potential pathways for improved sustainability (Shine et al., 2020).

2.4 Technological Advancements and Innovation

The adoption of Industry 4.0 technologies, termed "Dairy 4.0," is gaining momentum in the Indian dairy sector. Key enabling technologies include robotics, 3D printing, Artificial Intelligence, Internet of Things, Big Data, and blockchain (Hassoun et al., 2023). These advanced technologies are progressively being integrated across the dairy value chain, leading to transformative changes in milk and dairy product production (Hassoun et al., 2023).

2.5 Forecasting and Planning

To improve efficiency and reduce waste in the cold supply chain, forecasting models, such as ARIMA, are being used to predict monthly milk production trends (Kashyap et al., 2023). These forecasts help optimize demand-supply dynamics and align the dairy sector with Sustainable Development Goals (SDGs) (Kashyap et al., 2023).

2.6 Global Trends and Market Dynamics

The global dairy industry is undergoing significant transformation, characterized by expansion and consolidation amid rising competition from plant-based and synthetic milk alternatives (Bojovic and McGregor, 2022). Four key



megatrends have been identified: geographical shifts in production and consumption from the Global North to the Global South, intensification of production through mechanization and corporatization, growing awareness of ecological impacts, and disruptions caused by non-dairy alternatives (Bojovic & McGregor, 2022).

2.7 Health and Safety Concerns

Microbiological hazards are more frequently encountered in dairy products than chemical and physical hazards (Van Asselt et al., 2016). The major microbiological risks include Listeria monocytogenes, Staphylococcus aureus, Salmonella, and human pathogenic Escherichia coli, whereas aflatoxin M1, dioxins, and veterinary drug residues are key chemical hazards (Van Asselt et al., 2016). A systematic review of dairy consumption and cancer risk has shown conflicting evidence, with variability in study designs and overall low methodological quality affecting the conclusions (Jeyaraman et al., 2019). More rigorous research using high-quality prospective study designs is required to establish clearer associations. Similarly, a meta-analysis of dairy product consumption and asthma in children found no overall correlation between dairy intake and a reduced asthma risk. However, a subgroup analysis suggested a significant positive correlation between elevated dairy consumption and reduced asthma risk in non-Asian populations and high-quality studies (Song et al., 2023).

2.8 Socio-Economic Impacts

In rural India, the dairy industry plays a crucial role in socioeconomic development, particularly women's empowerment (Mor et al., 2018). With over 70 million women employed in the sector, dairy farming provides significant opportunities for financial independence and improved livelihood in rural communities.

III. OBJECTIVES

The Main Objective of this research paper are as follows 3.1 Study of trends in milk production in India.

3.2 To analyze various government initiatives for the dairy industry in India.

3.3 To identify the constraints and opportunities in the Indian dairy industry, we suggest remedial measures for its overall performance.

IV. METHODOLOGY

This study adopts a descriptive and analytical research approach to examine the trends in milk production, government initiatives, and constraints and opportunities in India's dairy industry. This research follows a descriptive research design to study milk production trends and analyze various government policies and initiatives. Additionally, an analytical approach is used to assess the challenges and opportunities in the dairy sector and suggest policy measures. This study primarily relied on secondary data collected from various government reports, academic journals, industry publications, and databases. Key sources include reports from the Department of Animal Husbandry and Dairying (DAHD) and the National Dairy Development Board (NDDB), publications from the Food and Agriculture Organization (FAO) and World Bank, research articles from peer-reviewed journals, and industry reports from financial institutions. The scope of this study focuses on the Indian dairy industry at the national level, covering trends, policies, and constraints. However, it does not include primary data collection, such as farmer surveys or field studies, and is dependent on the availability and accuracy of the secondary data. Despite these limitations, this study aims to provide valuable insights into the performance and challenges of the Indian dairy sector.

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V. RESULT AND DISCUSSION

5.1 Status of Dairy Sector in India

Table 1: Milk Production and Per Capita availability in India

Milk Produ	ction and Per Capita availabi	lity of Milk in India
Year	Production (Million Tonnes)	Per Capita availability (gms/day)
1991-92	55.6	178
1992-93	58	182
1993-94	60.6	186
1994-95	63.8	192
1995-96	66.2	195
1996-97	69.1	200
1997-98	72.1	205
1998-99	75.4	210
1999-2000	78.3	214
2000-01	80.6	217
2001-02	84.4	222
2002-03	86.2	224
2003-04	88.1	225
2004-05	92.5	233
2005-06	97.1	241
2006-07	102.6	251
2007-08	107.9	260
2008-09	112.2	266
2009-10	116.4	273
2010-11	121.8	281
2011-12	127.9	290
2012-13	132.4	299
2013-14	137.7	307
2014-15	146.3	322
2015-16	155.5	337
2016-17	165.4	355
2017-18	176.3	375
2018-19	187.7	394
2019-20	198.4	406
2020-21	210	427
2021-22	221.1	444
2022-23	230.6	459
2023-24	239.3	471

SOURCE: National Dairy Development Board (NDDB), GOI



Table 1 presents data on milk production and per capita availability of milk in India from to 1991-92 to 2023-24, showing a consistent upward trend over the period. Milk production increased from 55.6 million tonnes in 1991-92 to 239.3 million tonnes in 2023-24, reflecting a growth of over 330%. The growth rate was steady in the 1990s, with production increasing from 55.6 million tonnes in 1991-92 to 80.6 million tonnes in 2000-01, a rise of approximately 45% over the decade. The upward trend continued in the 2000s, with production reaching 121.8 million tonnes by 2010-11, nearly double the 1991-92 level. The most significant growth occurred after 2010, with production increasing from 121.8 million tonnes in 2010-11 to 239.3 million tonnes in 2023-24. The per capita milk availability also showed a steady increase during the same period. It rose from 178 g per day in 1991-92 to 217 g per day in 2000-01 and further increased to 281 g per day by 2010-11. After 2015, the growth in per capita availability accelerated, reaching 471 grams per day in 2023-24, more than 2.6 times the 1991-92 level. The most noticeable increase in both production and per capita availability occurred after 2010, suggesting an enhanced production capacity and increased domestic consumption. Decadal growth patterns reflect a consistent progress. Between 1991 and 2000, milk production increased by approximately 40% and per capita availability by 21%. From 2000 to 2010, production and per capita availability grew by 50% and 30%, respectively. Between 2010 and 2020, production increased by approximately 63% and per capita availability by 45%. The period from 2020 to 2024 shows a slow but steady rise, with production growing by 14% and per capita availability increasing by 10%. The increase in milk production and availability can be attributed to various factors, including improvements in dairy infrastructure, better veterinary services, technological advancements, and government initiatives, such as Operation Flood. The role of the cooperative sector, particularly organizations like Amul, has also contributed to enhancing production and distribution efficiency.

5.2 GOVERNMENT INITIATIVES

The Government of India has implemented several initiatives to enhance milk production and productivity of bovine animals in India. These initiatives aim to improve the genetic makeup of indigenous breeds, provide quality breeding services, and ensure better health care for livestock.

5.2.1 National Dairy Development Board

The National Dairy Development Board (NDDB), established in 1965 under Dr. Verghese Kurien, played a key role in transforming India into the largest milk producer through Operation Flood (1970–1996). The NDDB promotes dairy development by improving cattle productivity, supporting milk cooperatives, and enhancing milk quality through better breeding, feeding, and healthcare. Key initiatives include the National Dairy Plan (NDP) to boost milk production, Rashtriya Gokul Mission to preserve indigenous breeds, and Dairy Infrastructure Development Fund (DIDF) to strengthen processing and storage facilities. The NDDB's efforts have improved farmers' incomes, rural livelihoods, and milk availability.

5.2.2 Operation Flood

Operation Flood was launched in 1970 by the National Dairy Development Board under the leadership of Verghese Kurien. It aimed to make India self-sufficient in milk production and reduce its dependency on imports. The program connects rural milk producers with urban markets through a nationwide milk grid, ensuring a steady supply of milk and reducing price fluctuations. Implemented in three phases from 1970 to 1996, it focused on increasing milk production through improved cattle breeds, better feeding practices, and enhanced veterinary services. The establishment of milk cooperatives and modern storage and processing infrastructure played key roles in its success. Operation Flood helped India become the largest producer of milk globally, improving rural income and nutritional levels.

5.2.3 Rashtriya Gokul Mission

The Rashtriya Gokul Mission (RGM), launched in December 2014 by the Government of India, aims to conserve and develop indigenous bovine breeds while sustainably enhancing milk production. According to the Department of Animal Husbandry and Dairying, the mission focuses on breeds such as Gir, Sahiwal, Rathi, and Red Sindhi, which are known for their resilience and milk-producing abilities. Key initiatives include establishing Gokul Grams and integrated cattle development centers that provide breeding, feeding, and healthcare facilities. This mission promotes artificial insemination and natural services using indigenous bulls with high genetic merit to improve cattle quality. Programs such as Pashu Sanjivni use advanced technology for animal identification and traceability, while the National Bovine Genomic Center for Indigenous Breeds (NBGC-IB) supports genetic improvement. Awareness campaigns, training of farmers, and recognition of contributions further encourage the adoption of indigenous breeds. This mission has successfully increased awareness, improved genetic quality, and boosted milk production, aligning with India's goals of sustainable agriculture and rural development.

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5.2.4 National Programme for Dairy Development

The National Programme for Dairy Development (NPDD) was introduced in February 2014 by the Government of India to strengthen the dairy sector. The Department of Animal Husbandry, Dairying, and Fisheries, it focuses on increasing milk production, improving milk quality, and building sustainable infrastructure. The program supports dairy cooperatives and farmer-producer organizations, helping farmers access better markets and fair prices. It promotes clean milk production, modern processing techniques, and advanced breeding and feeding technologies. By establishing milk-chilling plants, processing units, and cold storage facilities, NPDD ensures efficient milk handling and distribution. Additionally, it provides training for farmers in modern dairy practices and animal health management. The programme has significantly boosted milk production, enhanced milk quality, and improved the livelihoods of dairy farmers, contributing to food security and sustainable agriculture in India.

5.2.5 Dairy Entrepreneurship Development Scheme

The Dairy Entrepreneurship Development Scheme (DEDS) was launched in 2010 as part of the National Livestock Mission, to encourage entrepreneurship in the dairy sector. Managed by the Department of Animal Husbandry, Dairying, and Fisheries, the scheme aims to create self-employment opportunities, boost milk production, and improve dairy-related infrastructure. It offers financial support to individuals, farmers, and groups to help them establish small-to medium-scale dairy businesses. The scheme covers a wide range of activities such as setting up dairy farms, milk chilling plants, veterinary clinics, and feed and fodder production units. It also supports heifer calf rearing to improve breed quality and provides assistance in milk transportation and marketing infrastructure. Financial help is provided through subsidies and loans, with special emphasis on marginalized groups, including women and small farmers. Depending on the beneficiary category, the scheme offers subsidies covering 25-33% of the project cost. Since its launch, DEDS have played a significant role in creating numerous dairy-based enterprises across the country. It has helped to increase milk production, improve dairy infrastructure, and provide sustainable livelihood opportunities, particularly in rural areas. By empowering farmers and promoting entrepreneurship, this scheme will contribute to rural development and economic growth in India.

VI. OPPORTUNITIES AND CHALLENGES

The dairy sector in India, one of the largest in the world, faces several challenges, including the low productivity of milch animals due to poor genetic quality, inadequate nutrition, and limited healthcare. A weak infrastructure for milk procurement, storage, and distribution leads to spoilage and quality issues. Small and marginal farmers struggle with limited access to credit and modern technology, whereas animal diseases, feed shortages, and high costs further impact production. Market inefficiencies dominated by middlemen make it difficult for farmers to obtain fair prices. Climate change adds to these challenges owing to erratic weather and water scarcity. Despite these issues, the sector has significant growth potential. The rising demand for milk and dairy products driven by population growth and increasing health awareness presents major opportunities. Government programs such as the National Programme for Dairy Development, the Rashtriya Gokul Mission, and the Dairy Entrepreneurship Development Scheme provide financial and technical support. Technological advances in breeding and milking systems can boost productivity. Cooperative models like Amul empower farmers and improve market access. The growing demand for value-added products, such as cheese and yogurt, offers diversification opportunities, while sustainable practices, such as biogas production and efficient water use, can enhance profitability and environmental impact. Skill development and training in modern dairy practices can improve productivity and quality.

VII. CONCLUSION AND POLICY RECOMMENDATION

India's dairy sector has become the largest milk producer globally, driven by initiatives such as Operation Flood, the National Programme for Dairy Development, and the Rashtriya Gokul Mission, which have improved production, infrastructure, and market access. However, challenges such as the low productivity of milch animals, inadequate storage and distribution infrastructure, limited access to credit and technology for small farmers, and animal health issues hinder the sector's full potential. Market inefficiencies and climate change further complicate this growth. To address these challenges, artificial insemination and genomic programs can be expanded to improve cattle productivity. Strengthening the infrastructure with milk-chilling plants, cold storage, and processing facilities will reduce spoilage and improve supply chains. Promoting farmer cooperatives and producer organizations can enhance market access and fair pricing. Improving veterinary services, vaccination, and feed availability can help sustain productivity. Encouraging value-added products such as cheese and yogurt can diversify income, while promoting sustainable

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practices, such as biogas production and efficient water use, will enhance resilience. Providing affordable credit, insurance, and training for small farmers boosts financial security and operational efficiency. Facilitating access to global markets through better-quality standards and export infrastructure will further strengthen India's dairy sector.

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