



Original Research Paper

GROWTH, GVA CONTRIBUTION AND STRUCTURAL CHALLENGES IN INDIA'S DAIRY SECTOR

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ABSTRACT

The dairy sector occupies a pivotal position in the Indian economy, contributing significantly to agricultural growth, rural employment, nutritional security and livelihood diversification. India is the world's largest milk producer, accounting for nearly 24 per cent of global output and producing 247.87 million tonnes of milk in 2024–25, with per capita availability of 485 g/day. Yet concerns remain regarding animal productivity, climate resilience, value addition and market competitiveness. Existing studies largely focus on production trends in isolation, with limited attention to integrating production growth with economic performance, rural livelihoods and future sustainability; this study addresses that gap. Using secondary data from government reports, annual publications and research studies for the period 1950–51 to 2024–25, the study applies growth-rate, Compound Annual Growth Rate (CAGR) and share-based analytical formulas to examine the sector's production performance, contribution to agricultural Gross Value Added, employment generation and structural challenges. The analysis shows milk production grew at a CAGR of approximately 3.7 per cent over the period, while livestock GVA grew considerably faster, at around 13.8 per cent per annum between 2011–12 and 2022–23, driven more by value addition than by volume growth. Persistent constraints include low animal productivity, fodder shortages, climate stress, disease outbreaks and marketing inefficiencies. The sector supports more than eight crore farming families, mainly small and marginal farmers. The paper concludes with formula-grounded policy recommendations for enhancing productivity, market efficiency and farmer welfare.

Keywords: Dairy Sector, Milk Production, Agricultural Economy, Livestock, Gross Value Added, Rural Development.

INTRODUCTION

Agriculture remains the backbone of the Indian economy, and the livestock sector plays a vital role in agricultural growth, rural employment, nutritional security and livelihood diversification (Economic Survey, 2024–25). Among the various livestock enterprises, dairy farming is the most important and widely practiced rural economic activity, particularly among small and marginal farmers. Dairy development in India gained remarkable momentum through Operation Flood, which transformed the country from a milk-deficient nation into the world's largest milk producer. The cooperative movement, particularly the Amul model, successfully integrated millions of milk producers into organized markets, ensuring remunerative prices and strengthening rural livelihoods.

Today, India accounts for nearly 24 per cent of global milk production, producing 247.87 million tonnes of milk during 2024–25, with a per capita milk availability of 485 g/day, well above the world average (DAHD, 2025a). The dairy sector contributes nearly 5 per cent to the national economy and forms the largest agricultural commodity segment in the country (DAHD, 2025a; FAO, 2023). Increasing population, rapid urbanization, rising incomes, changing dietary preferences, and growing demand for protein-rich foods continue to expand the domestic dairy market. At the same time, the adoption of modern agricultural technologies and data-driven approaches is increasingly important for improving agricultural productivity, resource management and sustainable agribusiness development (Singh & Kaur, 2025).

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Despite these achievements, the sector continues to face several challenges, including low productivity of dairy animals, shortage of quality feed and fodder, climate change, disease outbreaks, fragmented production systems, inadequate cold-chain infrastructure and marketing inefficiencies. Although several studies have examined individual aspects of dairy development, comprehensive assessments integrating production trends, economic contribution, employment generation and future sustainability are relatively limited.

Milk is an important component of human nutrition and provides essential nutrients, including proteins, vitamins and minerals. The quality and safety of milk are influenced by production and processing practices, with pasteurization playing an important role in reducing microbial contamination while maintaining the nutritional characteristics of milk (Abhang et al., 2024).

Against this background, the present study examines the economic performance of the dairy sector in India by analysing long-term growth trends, production performance, contribution to agricultural Gross Value Added (GVA), employment generation, major challenges and future prospects. The findings are expected to support evidence-based policymaking and contribute to sustainable dairy development in India.

Objectives of the Study

The present study was undertaken with the following objectives:

- i. To examine the growth and development of the dairy sector in India.
- ii. To analyze trends in milk production, per capita milk availability and growth performance over time.
- iii. To assess the economic contribution of the dairy sector to agricultural Gross Value Added (GVA), rural employment and livelihood generation.
- iv. To identify the major challenges affecting the sustainable growth of the dairy sector and suggest suitable policy measures for its future development.

REVIEW OF LITERATURE

The dairy sector has been widely recognized as one of the most dynamic components of Indian agriculture due to its contribution to rural livelihoods, employment generation, nutritional security and economic growth. In line with the objectives of the present study, this section reviews the existing academic and policy literature (largely 2013–2026) on the economic performance of India's dairy sector, organized around six themes: growth and development of the dairy sector; cooperative institutions and farmer income; productivity and technical efficiency; economic contribution to agricultural GVA and rural employment; structural, climate-related and marketing constraints; and the research gap that motivates the present study.

Growth and Development of the Dairy Sector

A substantial body of literature traces the growth trajectory of India's dairy sector to the institutional foundations laid by Operation Flood (1970–1996), coordinated by the National Dairy Development Board (NDDB) under Verghese Kurien. Retrospective assessments, including a World Bank evaluation, credit the programme with transforming India from a milk-deficient importer into the world's largest milk producer within roughly three decades, through the “Anand pattern” of village–district–state cooperative federation. Birthal and Taneja (2019), in their assessment of the livestock sector, similarly identify institutional development, breed improvement and expanding market access as the principal drivers of the sector's long-term growth. Kumar et al. (2025a), examining the performance of commercial dairy farming in Meerut district of Uttar Pradesh, report that production growth accelerated sharply after the 1970s and has since been sustained by cooperative expansion, veterinary service delivery and government development programmes. This early success has motivated a 2024 successor initiative, “White Revolution 2.0,” led by the Ministry of Cooperation, aimed at expanding cooperative coverage, strengthening the milk value chain and deepening women's participation.

Cooperative Institutions and Farmer Income

A large body of literature examines whether cooperative membership improves farmer welfare, generally concluding that cooperative membership raises farmgate prices and stabilizes household incomes relative to informal marketing channels. Studies using panel and propensity-score methods report similar positive effects: research on smallholder dairy farmers in Bihar found that cooperative membership improved household welfare (Kumar, Saroj, Takeshima & Joshi, 2018), and propensity-score matching work in Manipur found a positive economic impact of cooperative membership on farmer income (Priscilla & Chauhan, 2019). Survey-based work across Assam, Kerala, Gujarat, Punjab, Rajasthan and Karnataka consistently reports that cooperatives improve access to credit and veterinary services, while also noting persistent problems such as technology adoption gaps and price differentials between market and cooperative rates (Mahida, Chandel & Kumari, 2022).

A recurring finding is that cooperative benefits are not evenly distributed. Village-level fieldwork across two Indian states found that cooperative membership was associated with caste status and proximity to collection centres, with income gains concentrated among smallholders and the land-poor who are most dependent on dairy income (Gaillard & Dervillé, 2022). Karnataka-focused work similarly found land ownership to be a strong determinant of dairy profitability, with landholding farmers earning substantially more monthly revenue than landless farmers, and identified restricted credit access for women as a persistent constraint

(Farnworth, Ravichandran & Galié, 2023). Related research on women's dairy cooperatives documents gains in women's decision-making power over dairy income, though men are found to retain control over upstream decisions such as fodder cultivation (Farnworth, Ravichandran & Galié, 2023). Despite the cooperative movement's scale, the organized sector (cooperatives plus private processors) still handles only about one-third of marketable milk nationally, leaving the unorganized/informal sector dominant — a structural feature with implications for price transmission and farmer bargaining power that recurs throughout the literature (NDDB, 2024).

Productivity and Technical Efficiency

A distinct econometric literature uses Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA) to measure technical efficiency in Indian dairy production. Work in Uttarakhand found that smallholder producers were more technically efficient than larger producers, particularly in the plains, with market participation intensity positively associated with efficiency (Bardhan & Sharma, 2013). An Assam-focused DEA study found considerable scope for improving technical efficiency among smallholder dairy farms and identified factors such as fodder cultivation, market access, household characteristics and asset position as important determinants of efficiency (Bayan, Sahu & Dutta, 2025). At the macro level, India's productivity paradox is a recurring subject in the literature: despite producing roughly a quarter of the world's milk, average yield per animal remains about half the global average, a gap attributed to fragmented small-herd structures, uneven access to quality feed and genetics, and limited mechanization rather than to any single technological deficiency (Ohlan, 2013).

Economic Contribution to Agricultural GVA, Employment and Rural Livelihoods

Literature on the sector's macroeconomic contribution is comparatively less developed than the production-trend literature, though it is growing. Birthal and Taneja (2019) document the rising share of livestock, led by dairying, in agricultural Gross Value Added and attribute this to the relative income stability dairying offers compared with crop agriculture, which remains exposed to climatic variability. Nanda Kumar, Das and Gulati (2022) similarly note that milk has become the single largest agricultural commodity by value in India, exceeding the combined value of cereals, pulses and oilseeds, underscoring dairying's centrality to rural livelihood generation. Studies consistently describe dairying as a source of year-round, low-entry-barrier income for small and marginal households, and as complementary to crop production through the reuse of crop residues as feed and livestock manure as organic fertilizer.

Structural, Climate-Related and Marketing Constraints

A growing body of recent research (2024–2026) documents deceleration and vulnerability in milk production growth, with national growth rates reported to have slowed from around 6.6 per cent (2018–19) to under 4 per cent (2022–23 and 2023–24) (DAHD, 2024, 2025b). Assessments of the challenges and prospects of sustainable dairy farming in India attribute this deceleration to a combination of fodder scarcity, disease outbreaks (notably Lumpy Skin Disease and Foot-and-Mouth Disease), rising input costs and climate stress. Fodder deficits are a particularly well-documented constraint, with national studies estimating green fodder deficits in the range of 30–36 per cent against a land allocation for fodder cultivation that has remained roughly stagnant at under 5 per cent of gross cropped area for decades. Emerging climate-economics research quantifies heat-stress losses directly: a 2025–26 study centred on Haryana's trans-Gangetic plains, published in Scientific Reports, found that heat stress is a more significant driver of milk-yield loss than winter temperature variation, with current heat-related losses estimated at around 3.2 million tonnes of milk annually, projected to rise substantially by the 2050s absent adaptation (Kumar et al., 2025b). Separately, the literature identifies inadequate cold-chain infrastructure, milk adulteration and price volatility linked to global skim-milk-powder markets as recurring marketing-side constraints on farmer profitability (FAO, 2022; NDDB, 2023).

Research Gap

The literature reviewed above indicates that Indian dairy research has developed largely along separate, relatively self-contained strands: production-trend and growth-rate studies; cooperative-institution and farmer-income studies; technical-efficiency studies; and, more recently, climate-vulnerability studies. Comparatively few studies integrate long-term production performance with the sector's contribution to agricultural GVA, rural employment and livelihood security within a single analytical framework, and fewer still connect this integrated economic assessment to a forward-looking discussion of sustainability and policy. The present study addresses this gap by jointly examining growth trends, GVA and employment contribution, structural challenges and future prospects for India's dairy sector using an integrated, secondary-data-based analytical framework.

METHODOLOGY

Conceptual Framework

The economic performance of the dairy sector is influenced by a combination of government interventions, technological advancements and institutional support. Government policies and development programmes encourage the adoption of improved technologies, including artificial insemination, better breeding practices, veterinary healthcare, scientific feeding and modern dairy management. These technological interventions enhance milk production and

productivity, which increase farmers' income, generate rural employment, improve food and nutritional security, and ultimately contribute to overall economic growth.

The conceptual framework adopted in the present study is illustrated in Figure 1.

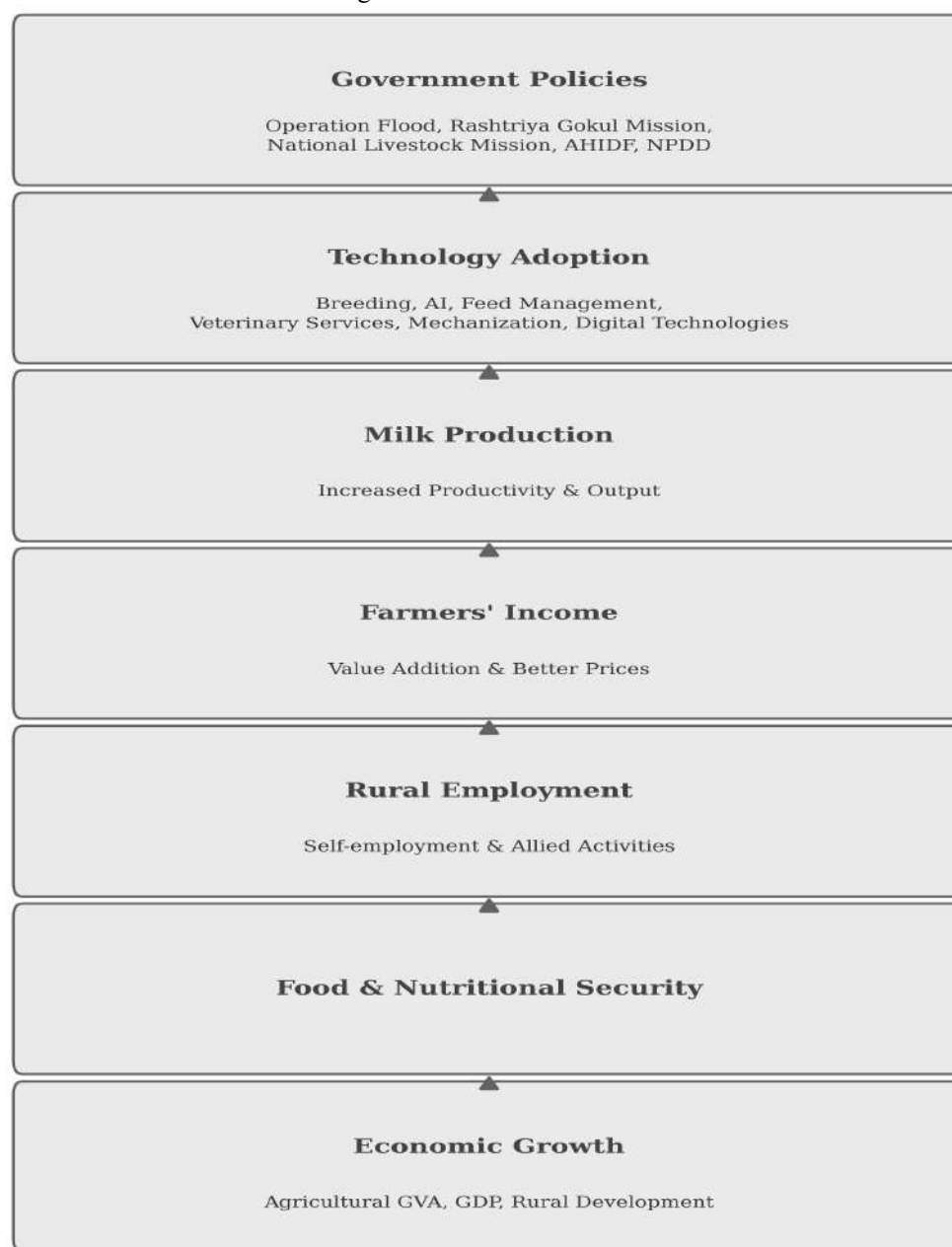


Figure 1. Conceptual framework of dairy sector development

Sources of Data and Study Period

This study adopts a descriptive-cum-analytical research design based exclusively on secondary data. Data were collected from various published sources such as the Department of Animal Husbandry and Dairying (DAHD), the National Dairy Development Board (NDDB), Basic Animal Husbandry Statistics (BAHS), National Accounts Statistics (MoSPI), the Economic Survey of India, the Food and Agriculture Organization (FAO) and other published research articles and government reports.

The analysis covers the period 1950–51 to 2024–25, depending on data availability. The study examines trends in milk production, per capita milk availability, growth rates, state-wise milk production, the contribution of the livestock sector to Agricultural Gross Value Added (GVA), employment generation and the overall economic performance of the dairy sector.

Descriptive statistical tools such as percentage analysis, growth-rate analysis, trend analysis and comparative analysis were employed to examine changes over time and compare the performance of key indicators. The results are presented through tables and figures and

interpreted to evaluate the growth trajectory, economic significance, challenges and future prospects of the dairy sector in India.

Analytical Formulas Used in the Study

To ensure analytical rigor, the following standard formulas were applied for computing growth rates, shares and productivity indicators used in the results and discussion section.

Compound Annual Growth Rate (CAGR)

$$CAGR (\%) = [(P_n / P_0)^{(1/n)} - 1] \times 100$$

Where P_n = value of the variable (e.g., milk production) in the terminal year, P_0 = value of the variable in the base year, and n = number of years between the base year and the terminal year. CAGR was used to compute the long-term growth performance of milk production, per capita availability and livestock GVA.

Point-to-Point (Annual) Growth Rate

$$Growth Rate (\%) = [(Y_t - Y_{t-1}) / Y_{t-1}] \times 100$$

Where Y_t is the value of the variable in the current period and Y_{t-1} is the value in the immediately preceding period. This measure was used to compute the year-on-year and plan-period growth rates of milk production.

Percentage Share / Contribution Ratio

$$Share (\%) = (Component Value / Total Value) \times 100$$

This formula was applied to compute the share of livestock GVA in Agricultural and Allied GVA, the share of individual states in national milk production, and India's share in global milk production.

Per Capita Milk Availability

$$Per\ Capita\ Milk\ Availability\ (g/day) = (Total\ Milk\ Production\ (tonnes) \times 1000) / (Mid-Year\ Population \times 365)$$

This formula was used to derive the per capita milk availability and to assess the adequacy of milk supply relative to population growth over time.

Productivity Gap Index

$$Productivity\ Gap\ (\%) = [(Yield_World - Yield_India) / Yield_World] \times 100$$

This index was used to quantify the extent to which average milk yield per animal in India lags behind the world average yield.

RESULTS AND DISCUSSION

Status of the Dairy Sector in the World

The dairy sector plays a vital role in global agriculture, contributing significantly to food security, nutrition, employment and rural livelihoods. Global milk production has shown a steady increase over the past three decades, rising from approximately 530 million tonnes in 1990 to 906 million tonnes in 2020. This growth has been driven by increasing demand for milk and dairy products, population growth, urbanization and improvements in dairy farming practices.

India emerged as the world's largest milk producer in 2020, accounting for 21.9 per cent of global milk production, followed by the United States and Pakistan. Several developing countries, particularly in Asia, have experienced substantial growth in milk production, reflecting the expanding importance of the dairy sector in these regions. Table 1 presents the trends in milk production, global production shares and rankings of major milk-producing countries from 1990 to 2020.

Table 1. Milk production, global share, and ranking of major milk-producing countries (1990–2020)

Country	Prod. 1990 (Mt)	Prod. 2000 (Mt)	Prod. 2010 (Mt)	Prod. 2020 (Mt)	Share 1990 (%)	Share 2000 (%)	Share 2010 (%)	Share 2020 (%)	Rank 2020
India	53.68	79.66	121.85	198.40	10.1	13.6	16.7	21.9	1
United States	67.01	76.02	87.46	101.10	12.6	13.0	12.0	11.2	2
Pakistan	14.72	25.57	35.49	60.70	2.8	4.4	4.9	6.7	3
China	7.04	12.37	41.14	35.70	1.3	2.1	5.6	3.9	4
Brazil	15.08	20.53	31.82	35.40	2.8	3.5	4.4	3.9	5
Germany	31.34	28.35	29.67	33.20	5.9	4.8	4.1	3.7	6
Russia	55.70	32.28	32.14	32.20	10.5	5.5	4.4	3.6	7
France	26.81	25.74	24.25	24.60	5.1	4.4	3.3	2.7	8
Turkey	8.61	10.63	13.54	23.50	1.6	1.8	1.9	2.6	9
New Zealand	7.51	12.24	17.01	21.90	1.4	2.1	2.3	2.4	10
World	530.00	586.00	730.00	906.00	100.0	100.0	100.0	100.0	—

Source: National Dairy Development Board (NDDB), Government of India, Global/Country-wise Milk Production Statistics (1990, 2000 and 2010); FAOSTAT International Dairy Statistics (2020). Global production shares were calculated on the basis of world milk production totals.

The data reveal that global milk production increased by approximately 71 per cent between 1990 and 2020.

Among the top milk-producing countries, India exhibited the highest absolute growth and significantly

strengthened its dominance in the global dairy sector. While traditional dairy producers such as the United States, Germany and France continued to contribute substantially to world production, their relative shares declined over time. In contrast, emerging dairy economies, particularly India and Pakistan, expanded both production volume and global market share. This trend suggests a structural transformation in the global dairy industry, driven by increasing demand, technological improvements and livestock development in developing nations.

the dairy sector over time.

Dairy Sector Scenario in India

The dairy sector has experienced remarkable growth since independence and has become one of the most important components of Indian agriculture. Through initiatives such as Operation Flood, expansion of dairy cooperatives and technological advancements, India has emerged as the world's largest milk producer. Figure 2 presents the trends in milk production and per capita milk availability in India from 1950–51 to 2024–25, highlighting the progress and development of

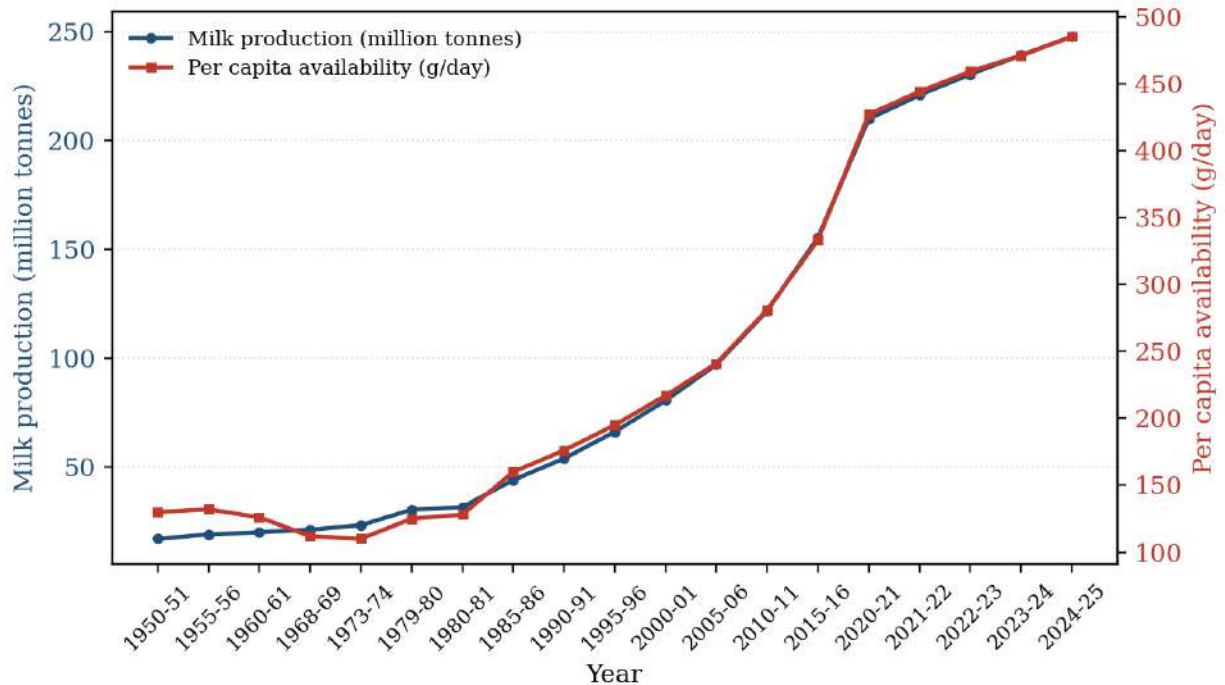


Figure 2. Trend in milk production and per capita milk availability in India (1950-51 to 2024-25)

Source: Basic Animal Husbandry Statistics (BAHS), Department of Animal Husbandry & Dairying, Government of India; National Dairy Development Board (NDDB, 2024).

Figure 2 reveals a remarkable expansion of the dairy sector in India over the last seven decades. Milk production increased from 17 million tonnes in 1950–51 to 247.87 million tonnes in 2024–25, representing more than a fourteen-fold increase. Simultaneously, per capita milk availability rose from 130 g/day to 485 g/day, indicating substantial improvement in the accessibility of milk and dairy products to the population.

Despite the rapid growth in India's population, which increased from 359 million in 1950–51 to approximately 1.4 billion in 2024–25, milk production expanded at a faster rate, resulting in improved nutritional security. Significant growth periods can be observed during the implementation of Operation Flood and subsequent dairy development programmes, which strengthened milk procurement, processing and marketing infrastructure across the country.

The consistently increasing trend in milk production demonstrates the resilience and economic importance of the dairy sector. The findings highlight that dairy farming has become a major contributor to agricultural growth, rural employment and income generation. Overall, the data confirm that India's dairy sector has achieved substantial progress and continues to play a crucial role in ensuring food security, supporting rural livelihoods and contributing to the national economy.

Growth Rate of Milk Production in India

The growth rate of milk production is an important indicator of the performance and development of the dairy sector in India. Since independence, milk production has shown a remarkable increase due to various government initiatives, technological advancements, breed improvement programmes, veterinary services and the successful implementation of

Operation Flood. The establishment of dairy cooperatives and strengthening of milk procurement and marketing

systems have played a significant role in enhancing milk production across the country.

Table 2. Growth rate of milk production in India (1950-51 to 2024-25)

Period	Growth rate (%)	Five-Year Plan	Growth rate (%)
1950-51 to 1960-61	1.64	5th Plan (1974-75 to 1978-79)	2.91
1960-61 to 1973-74	1.15	6th Plan (1980-81 to 1984-85)	6.42
1973-74 to 1980-81	4.51	7th Plan (1985-86 to 1989-90)	4.37
1980-81 to 1990-91	5.48	8th Plan (1992-93 to 1996-97)	4.41
1990-91 to 2000-01	4.11	9th Plan (1997-98 to 2001-02)	4.08
2000-01 to 2010-11	4.22	10th Plan (2002-03 to 2006-07)	3.64
2010-11 to 2015-16	5.00	11th Plan (2007-08 to 2011-12)	4.33
2015-16 to 2024-25	5.31	12th Plan (2012-13 to 2016-17)	5.51

Source: Basic Animal Husbandry Statistics (BAHS), Department of Animal Husbandry & Dairying, Government of India; National Dairy Development Board (NDDB).

The data reveal that milk production in India experienced relatively slow growth during the initial decades after independence. Between 1950-51 and 1973-74, the annual growth rate remained below 2 per cent, indicating limited technological and infrastructural development in the dairy sector. However, the introduction of Operation Flood in the 1970s significantly transformed the dairy industry, resulting in a growth rate of 4.51 per cent during 1973-74 to 1980-81. The period from 1980-81 to 1990-91 recorded a growth rate of 5.48 per cent, reflecting the positive impact of cooperative dairy development, improved breeding practices and enhanced veterinary services. Among the Five-Year Plans, the Sixth Plan achieved the highest growth rate of 6.42 per cent, demonstrating the effectiveness of dairy development programmes implemented during that period.

In recent years, milk production has continued to grow steadily. The growth rate of approximately 5.31 per cent between 2015-16 and 2024-25 highlights the increasing

efficiency and productivity of the Indian dairy sector. This sustained growth has enabled India to maintain its position as the world's largest milk producer and has significantly contributed to rural employment, income generation, nutritional security and agricultural economic growth.

State-wise Status of Milk Production in India

India occupies the first position in global milk production, and the dairy sector serves as a major source of income, employment and nutritional security. Milk production across states differs considerably due to variations in livestock population, breed composition, availability of feed and fodder resources, dairy infrastructure, cooperative networks and government support programmes. An assessment of state-wise milk production provides insights into regional disparities and the contribution of different states to national dairy development. Figure 3 presents the milk production of the ten leading dairy-producing states in India in 2023-24.

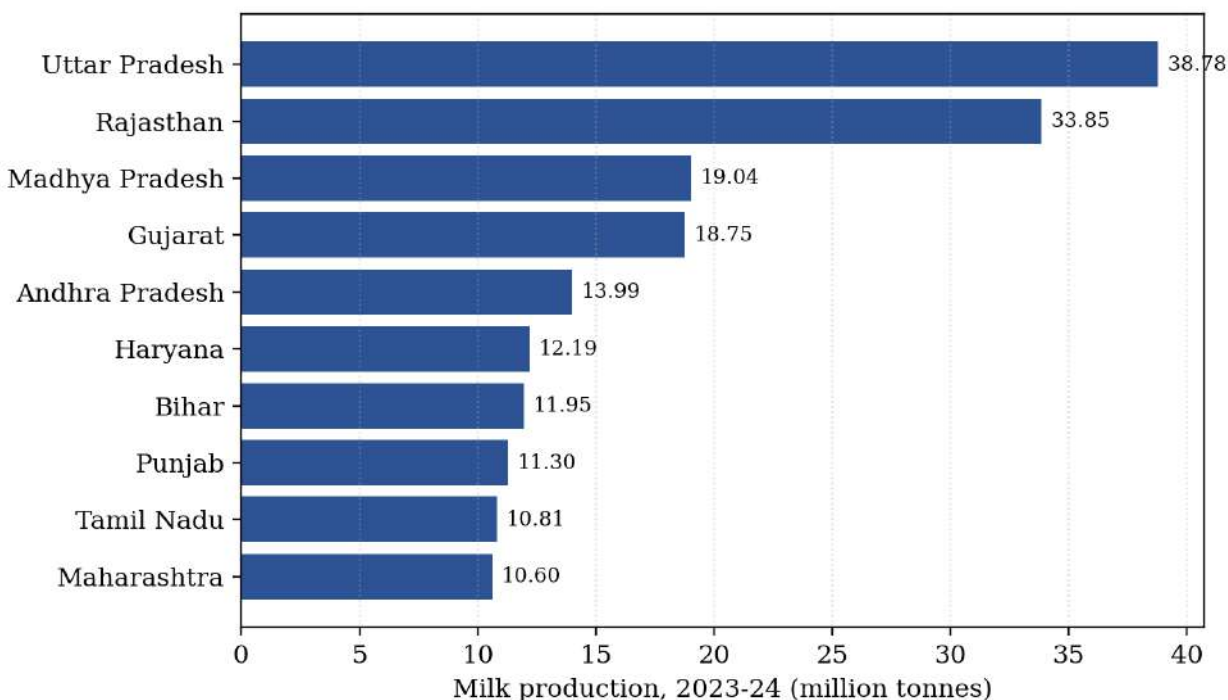


Figure 3. State-wise milk production in India, 2023-24 (million tonnes)

Source: National Dairy Development Board (NDDB), *State-wise Estimates of Milk Production ('000 tonnes)*; Basic Animal Husbandry Statistics (BAHS), Department of Animal Husbandry & Dairying, Government of India, 2024. Andhra Pradesh figures after state bifurcation are reported according to official NDDB/BAHS estimates.

Figure 3 indicates the milk production across the leading dairy-producing states in 2023-24. Uttar Pradesh occupied the leading position, reaching approximately 38.78 million tonnes in 2023-24. Rajasthan recorded remarkable growth and emerged as the second-largest producer, with about 33.85 million tonnes. Madhya Pradesh and Gujarat also exhibited strong output, at 19.04 million tonnes and 18.75 million tonnes respectively, due to improvements in dairy infrastructure, breed development and cooperative support systems.

The combined contribution of the top ten milk-producing states accounts for a major share of India's total milk production. The steady rise in production reflects the success of dairy development programmes, expansion of cooperative networks, improved animal health services and increasing adoption of scientific dairy farming practices. The growth of milk production has

strengthened rural livelihoods, enhanced nutritional security and contributed significantly to agricultural economic development in India.

Contribution of the Dairy Sector to Agricultural Gross Value Added (GVA)

The dairy sector is one of the most important components of the livestock economy and plays a significant role in India's agricultural development. Besides providing nutritional security and employment opportunities, dairying contributes substantially to the income generated from the agricultural sector. Gross Value Added (GVA) is an important economic indicator used to measure the contribution of different sectors to the economy. Figure 4 presents the trends in Agricultural and Allied GVA, Livestock GVA, and the share of livestock in Agricultural GVA from 2011-12 to 2022-23.

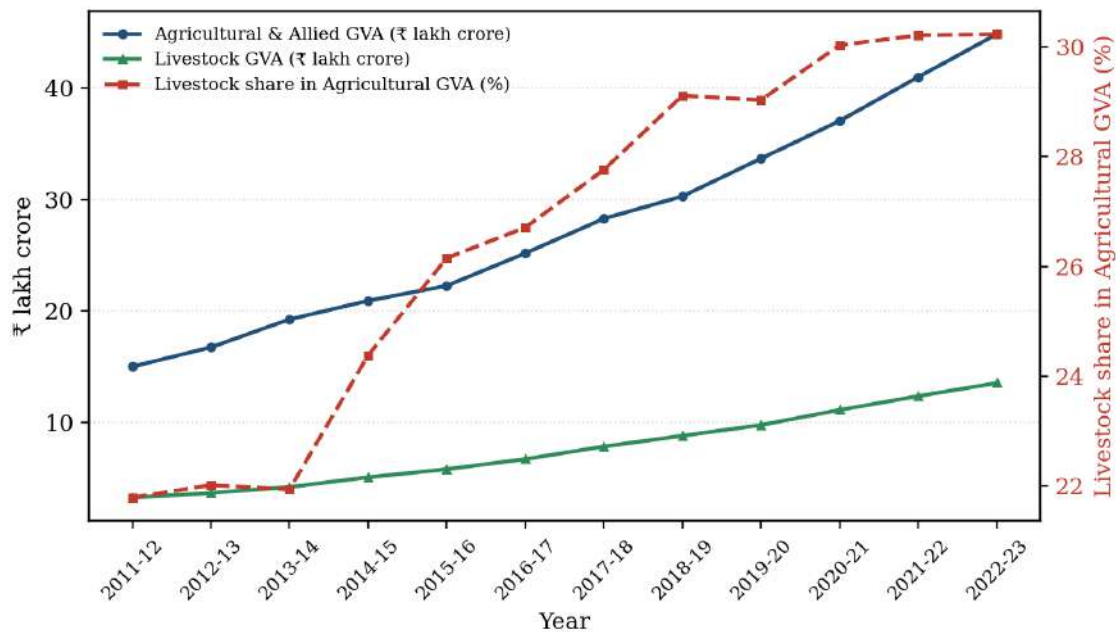


Figure 4. Agricultural & Allied GVA, Livestock GVA and livestock share in Agricultural GVA (2011-12 to 2022-23)

Source: National Dairy Development Board (NDDB, 2024); National Accounts Statistics (MoSPI, 2023).

Figure 4 indicates a significant increase in the contribution of the livestock sector to India's agricultural economy during the period 2011-12 to 2022-23. Agricultural and Allied Gross Value Added (GVA) increased from ₹15.02 lakh crore in 2011-12 to ₹44.84 lakh crore in 2022-23, while Livestock GVA rose from ₹3.27 lakh crore to ₹13.55 lakh crore during the same period.

The share of the livestock sector in Agricultural and Allied GVA increased from 21.79 per cent in 2011-12 to 30.23 per cent in 2022-23, demonstrating the growing economic significance of livestock-based activities. The continuous rise in livestock GVA can be attributed to increasing milk production, expansion of dairy cooperatives, improved animal health services, adoption of scientific dairy farming practices and rising demand for milk and dairy products.

The livestock sector exhibited relatively stable growth even during periods of fluctuation in crop production, highlighting its resilience and its role as a dependable source of income for rural households. Since dairying constitutes the largest component of the livestock sector, the increasing share of livestock GVA reflects the substantial contribution of dairy farming to agricultural growth, employment generation and rural development. The findings suggest that the dairy sector has become a key driver of agricultural transformation and income diversification in India, thereby strengthening the overall agricultural economy.

Contribution of Dairy Sector to the Livestock Sector

The dairy sector is the most important component of the livestock sector in India and contributes the largest share

to livestock output. Milk and milk products account for more than two-thirds of the total value of livestock output, making dairying the backbone of the livestock economy. The continuous growth in milk production, expansion of dairy cooperatives, and increasing demand for dairy products have significantly strengthened the livestock sector's contribution to agricultural income and national economic growth.

India's livestock sector has demonstrated consistent growth over the years, with dairying emerging as its dominant enterprise. The dairy industry supports a vast network of producers, processors, transporters and marketers, thereby creating value throughout the supply chain. The sector not only contributes substantially to Gross Value Added (GVA) but also provides a stable source of income compared with crop-based agriculture, which is often affected by climatic uncertainties.

Employment Generation through the Dairy Sector

The dairy sector is one of the largest sources of rural employment in India. It provides direct and indirect employment opportunities to millions of farmers, labourers, milk collectors, transporters, veterinarians and workers engaged in milk processing and marketing activities. Unlike seasonal crop farming, dairy farming generates income and employment throughout the year, making it a reliable livelihood option for rural households.

The sector supports more than eight crore farming families, most of whom are small and marginal farmers. Dairy farming requires relatively low initial investment and can be integrated with crop production systems, enabling farmers to utilize crop residues as animal feed

and livestock manure as organic fertilizer. The employment opportunities generated by dairying contribute significantly to poverty reduction, income diversification and rural economic development.

Challenges Faced by the Dairy Sector in India

Despite being the world's largest milk producer, the Indian dairy sector faces several challenges that hinder its growth and efficiency. One of the major constraints is the low productivity of dairy animals, which is significantly lower than that of dairy animals in developed countries. Factors such as poor genetic potential, inadequate breeding practices and insufficient nutrition contribute to lower milk yields (NDDB, 2023).

Another significant challenge is the shortage of quality feed and fodder. Increasing pressure on agricultural land, seasonal variations in fodder availability, and rising feed costs adversely affect dairy production. Animal health problems, including diseases such as Foot and Mouth Disease (FMD), mastitis and brucellosis, further reduce productivity and result in economic losses for farmers.

The dairy sector in India is predominantly characterized by small and marginal farmers owning a few dairy animals. This fragmented production system limits the adoption of advanced technologies and efficient management practices. In addition, inadequate infrastructure for milk collection, chilling, storage and transportation often leads to quality deterioration and post-harvest losses.

Price fluctuations and increasing input costs pose economic challenges for dairy farmers, affecting their profitability and income stability. Climate change has emerged as another concern, as rising temperatures, water scarcity and extreme weather events negatively impact animal health and milk production. Furthermore, limited access to institutional credit, livestock insurance and modern extension services restricts the ability of farmers to invest in productivity-enhancing measures.

Quality and safety issues, including milk adulteration and contamination, continue to affect consumer confidence and market competitiveness. Strengthening infrastructure, improving animal genetics and healthcare, ensuring adequate feed resources and enhancing market access are essential for overcoming these challenges and achieving sustainable growth in the Indian dairy sector.

Future Prospects of the Dairy Sector in India

The future of the dairy sector in India appears promising in view of increasing demand for milk and milk products, rising population, urbanization and growing consumer awareness regarding nutrition and health. India is expected to maintain its position as the world's leading milk producer, supported by favourable government policies, technological advancements and continuous improvements in animal husbandry practices.

Advances in breeding technologies, artificial insemination, genomic selection and improved veterinary

healthcare are expected to enhance the productivity of dairy animals. The adoption of scientific feeding practices, balanced nutrition and better fodder management will further contribute to increased milk production and improved animal health. Digital technologies, including precision dairy farming, mobile-based advisory services and automated milking systems, are likely to improve farm efficiency and profitability.

The growing demand for value-added dairy products such as cheese, yogurt, probiotic beverages, flavoured milk and dairy-based nutritional supplements offers significant opportunities for industry expansion. Increasing consumer preference for high-quality and packaged dairy products is expected to drive investments in processing, cold-chain infrastructure and quality assurance systems.

Government initiatives such as the National Programme for Dairy Development (NPDD), the Rashtriya Gokul Mission and the Dairy Infrastructure Development Fund (DIDF) are expected to strengthen dairy infrastructure, improve productivity and enhance market access. Furthermore, the dairy sector has considerable potential for generating rural employment, empowering women and increasing the income of small and marginal farmers. With sustained investments in technology, infrastructure, animal health and value addition, the Indian dairy sector is well positioned to achieve sustainable growth, enhance farmer livelihoods and contribute significantly to the country's agricultural economy in the coming years.

POLICY SUGGESTIONS AND RECOMMENDATIONS

The following formula-grounded policy measures are suggested to strengthen the economic performance of India's dairy sector.

Closing the Productivity Gap

Applying the Productivity Gap formula, India's average milk yield per animal remains close to 50 per cent below the world average (Ohlan, 2013). Using the CAGR formula in reverse, the annual yield growth rate required to close half of this gap (i.e., to raise average yield to 1.5 times its current level) within a 10-year policy horizon can be derived as:

$$\text{Required Yield Growth (\%)} = [(1.5)^{(1/10)} - 1] \times 100 \approx 4.1\% \text{ per annum}$$

This indicates that a sustained annual productivity growth of at least 4 per cent — achieved through genomic selection, sexed-semen technology, balanced ration formulation and expanded artificial insemination coverage — is necessary to make a meaningful dent in the productivity gap within a decade.

Accelerating Farmer Income Growth through Cooperative Expansion

Using the CAGR formula, livestock GVA grew at approximately 13.8 per cent per annum (nominal terms) between 2011-12 and 2022-23. Applying the doubling-

time approximation, Doubling Period (years) = $70 / \text{CAGR} (\%)$, a sustained nominal growth rate of 13.8 per cent implies a doubling period of roughly 5 years, while in real (inflation-adjusted) terms — assuming annual inflation of around 6 per cent, giving a real growth rate of approximately 7.8 per cent — the doubling period extends to approximately 9 years. Policy measures such as wider cooperative coverage, direct benefit transfers for milk procurement and reduction of intermediary margins should aim to sustain or improve upon this real growth rate in order to meet the objective of doubling farmers' real dairy income within a single decade.

Targeting Future Production and Per Capita Availability

The Per Capita Availability formula can be applied in reverse to set production targets. For instance, to raise per capita milk availability from the current 485 g/day (2024-25) to a policy target of 600 g/day by 2034-35 (a 10-year horizon), assuming population reaches approximately 1,520 million, the required production target works out to:

$$\text{Target Production} = (600 \times 1,520 \text{ million} \times 365) / 1000 \approx 333 \text{ million tonnes}$$

Applying the CAGR formula to this target relative to current production (247.87 million tonnes), the required compound annual growth rate is:

$$\text{Required CAGR} = [(333 / 247.87)^{(1/10)} - 1] \times 100 \approx 3.0\% \text{ per annum}$$

Since the sector has already achieved a growth rate of 5.31 per cent during 2015-16 to 2024-25 (Table 2), this target of 3.0 per cent per annum is comfortably achievable provided current momentum is sustained through continued investment in breeding, fodder security and cooperative infrastructure.

Strengthening Price Realization and Market Efficiency

Policymakers should monitor and improve the Price Realization Ratio, defined as:

$$\text{Price Realization Ratio} (\%) = (\text{Farmer Price Received} / \text{Consumer Retail Price}) \times 100$$

A higher ratio indicates a more efficient and equitable value chain. Strengthening cold-chain infrastructure, reducing the number of intermediaries and expanding direct farmer-to-cooperative procurement channels would improve this ratio and directly enhance farmer profitability.

Building Climate and Fodder Resilience

Given the persistent green fodder deficit of 30-36 per cent identified in the literature, policy support for fodder cultivation on at least 8-10 per cent of gross cropped area (up from the current stagnant share of under 5 per cent), together with fodder banks, silage promotion and heat-tolerant breed development, is essential to safeguard the productivity gains projected against climate-related risks.

CONCLUSION

The dairy sector plays a vital role in the Indian economy by contributing significantly to agricultural growth, rural employment, nutritional security and livelihood improvement. Over the years, India has emerged as the world's largest milk producer, demonstrating remarkable progress in milk production through the combined efforts of dairy farmers, cooperatives, private enterprises and government initiatives. The sector provides a stable source of income for millions of rural households, particularly small and marginal farmers, while also promoting women's participation in economic activities.

Applying the Compound Annual Growth Rate to the study's own data confirms this progress in quantitative terms: milk production grew at a CAGR of approximately 3.7 per cent per annum over the 1950-51 to 2024-25 period (from 17.00 to 247.87 million tonnes), per capita milk availability grew at a CAGR of approximately 1.8 per cent per annum over the same period (from 130 to 485 g/day), and livestock GVA grew at a considerably faster nominal CAGR of approximately 13.8 per cent per annum between 2011-12 and 2022-23. The gap between production growth and GVA growth underscores that value addition, and not volume growth alone, has been the principal driver of the sector's rising economic contribution in recent years.

Despite its achievements, the dairy sector continues to face challenges related to low animal productivity, feed and fodder shortages, animal health issues, inadequate infrastructure and market inefficiencies. Addressing these constraints through scientific management practices, technological innovations, improved veterinary services and strengthened supply chains is essential for sustaining growth.

With increasing domestic demand, expanding value-added dairy markets and supportive government policies, the future of the Indian dairy sector remains highly promising. As indicated by the formula-based projections in the preceding section, sustaining a compound annual growth rate of at least 3.0 per cent in milk production, alongside a productivity growth rate of around 4.0 per cent per annum to narrow the yield gap with global benchmarks, would be sufficient to meet future demand while further strengthening farmer incomes. Continued investment in productivity enhancement, infrastructure development and farmer empowerment will further strengthen the sector's contribution to agricultural development, rural prosperity and national economic growth.

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