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Milk and milk products as instruments of food and nutrition security in India: A situational analysis

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Abstract
India's dairy sector is under mounting pressure as climate change, rising input costs and structural vulnerabilities converge on smallholder producers who supply most of the country's milk. This article examines the evolving cost structure of milk production in India, with particular focus on the dominant role of feed and fodder, the incidence of distress cattle sales, and the interaction between production economics and subsidy schemes. Evidence from recent farm-level and national studies shows that feed and fodder typically account for 55-70 percent of the total cost of producing a liter of milk, while labor, veterinary services, power and fixed costs together form the remaining 30-45 percent. Climate-induced fodder scarcity and water stress are raising these feed shares further, eroding margins and forcing asset-poor farmers to liquidate cattle herds at distressed prices, which undermines long-term productivity and household resilience. At the same time, state-level milk incentives and cattle-feed subsidies partially offset these pressures by lowering the effective cost per liter or augmenting the price received, although they do not change the underlying economic cost of resource use. By integrating cost-of-production evidence, climate impacts, emerging trends in trade, and policy responses, the article argues that future dairy viability and nutrition security in India hinge on a "fodder- and water-smart" transformation that reduces feed costs per liter while protecting smallholders from climate and market shocks.

Keywords: Food security, nutrition security, dairy consumption, milk production, India dairy policy, livestock livelihoods

Introduction

Dairy, food security and Indian diets

India faces a dual nutrition challenge: Though the country has been self-sufficient in terms of food production, persistent undernutrition among children and women coexists with rising diet-related non-communicable diseases. Food and nutrition security in India increasingly hinges on access to not only sufficient calories but also diverse, nutrient-dense foods that can reduce stunting, wasting and micronutrient deficiencies among vulnerable populations [1]. Within a predominantly cereal-based dietary pattern, milk and dairy products occupy a distinctive position because they supply high-quality animal protein and multiple essential micronutrients at relatively low cost compared with other animal-source foods [1-4].

Food and nutrition security is commonly understood as a condition in which all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs for a healthy life [5]. In India, despite decades of economic growth, high levels of child undernutrition and micronutrient deficiencies persist, especially among low-income and marginalized groups [5, 6]. Diets remain heavily concentrated in cereals, with relatively low intakes of nutrient-dense animal-source foods; in this context, dairy products can substantially enhance diet quality by complementing staples and pulses [1, 4].

Dairy products are widely accepted across religious and cultural groups in India, unlike some other animal-source foods, and they fit well within vegetarian dietary norms that prevail in many regions [1]. The expansion of dairy production since the Green Revolution and Operation Flood has also increased the physical availability of milk, helping embed dairy in daily diets through tea, curds, buttermilk and ghee, even among poorer rural households [7, 8]. However, intake levels vary sharply by income, caste, gender and geography, which shapes the extent to which dairy can improve nutrition for different population segments [1, 9].

Nutrient profile and health effects

Milk and dairy products are characterized by a favorable nutrient profile, including complete proteins that supply all essential amino acids, abundant calcium and phosphorus, and several B-group vitamins such as riboflavin and vitamin B12 [1, 3]. Fortified liquid milk and milk powders can also provide vitamins A and D, addressing common deficiencies in Indian populations where sunlight exposure or dietary diversity may be limited [1, 2]. These nutrients are critical for linear growth, bone mineralization, immune function and neurocognitive development, particularly in early childhood and adolescence [1, 10].

Epidemiological research supports a beneficial association between dairy intake and child growth outcomes in India. A nationally representative analysis of children aged 6-59 months found that dairy milk consumption was associated with significantly lower odds of stunting, underweight and composite index of anthropometric failure, even after adjusting for socio-economic and environmental covariates [11, 12]. International comparative work suggests that increases in per-capita milk consumption correlate with reductions in child stunting across multiple low- and middle-income countries, reinforcing the potential of dairy as a growth-promoting food when integrated into broader nutrition strategies [10]. At the same time, the literature cautions that dairy is not a stand-alone solution; benefits are greatest when milk complements diversified diets and coexists with improvements in sanitation, healthcare and caregiving practices [11, 10].

Dairy sector growth, consumption and food availability

India has emerged as the world's largest milk producer, contributing about 22-25 percent of global milk output and making milk the country's single largest agricultural commodity by value [13, 14]. Between 2014-15 and 2023-24, national milk production rose from about 146 million tons to roughly 239-240 million tons, while per-capita availability increased to about 471 g per person per day [13, 15, 16]. These gains reflect long-term investments in cooperative structures, veterinary services, breeding, feed management and cold-chain infrastructure initiated under Operation Flood and consolidated through programs such as the National Dairy Plan and National Programme for Dairy Development [7, 17, 18].

Market integration has been a central feature of India's dairy transformation, shaping how milk and dairy products contribute to nutrition security across regions and social groups [7]. The cooperative model pioneered by Operation Flood linked millions of smallholders to organized procurement networks, enabling daily collection of small milk surpluses, bulk cooling and processing, and subsequent distribution through urban and rural retail channels [7, 18]. Over time, the rise of private dairies, contract arrangements with large processors, organized retail chains and e-commerce platforms has further extended cold-chain infrastructure and diversified product portfolios-ranging from pouched milk to ultra-high temperature (UHT) milk, curd, yogurt and fortified beverages-thereby stabilizing prices and improving year-round availability for consumers [18, 19]. Yet integration remains uneven: surplus states such as Gujarat, Punjab and Haryana are far better connected to formal value chains than eastern and north-eastern states, and a substantial share of milk in many regions still moves through informal vendors, where quality assurance and price transmission can be weak [8, 19]. Strengthening last-mile infrastructure, producer organizations and transparent pricing mechanisms is therefore critical to ensure that market integration not only raises farm incomes but also enhances the affordability, safety and regular access to dairy products for nutritionally vulnerable households [9, 20].

Table 1 compares the per capita consumption in different countries and geographic regions across the world. From a global perspective, India's per-capita milk availability now exceeds the world average, although it remains below typical levels in many high-income dairy-consuming regions such as the European Union and North America [21, 22, 23].

Table 1: Indicative per-capita milk availability/consumption, selected regions

Country/region	Approx. per-capita milk availability or consumption*	Interpretation
India	471 g/person/day (About172 kg/year) in 2023-24 [13, 21, 15]	Medium-high; above global average, but with large internal inequalities in access.
Global average	322 g/person/day (About118 kg/year) around 2023-24 [21]	Serves as a benchmark; India is above this average in availability terms.
World average (fresh dairy)	About 305 g/person/day (About111 kg/year) in early 2020s [22]	Similar order of magnitude as the global average in the previous row.
High-consumption countries (e.g., EU, North America, Argentina)	Typically over150 kg/capita/year, often substantially higher [23, 24]	Higher intake levels, with dairy contributing a larger share of dietary energy and protein.
Medium-consumption band (category including India, Pakistan, Japan, etc.)	30-150 kg/capita/year in many FAO classifications [23]	India's current availability places it at the upper end of this "medium" band.
*Notes: Figures for India are mainly from Government of India and related summaries; "global average" and regional bands derive from FAO and international dairy outlooks, which use slightly different reference years and product coverage [13, 21, 22, 23, 24].		

Analyses of NSSO and HCES data consistently demonstrate that milk is a normal good with positive income elasticity in India, though estimates vary by methodology and income group. The NDDB's comprehensive QUAIDS study using multiple NSS rounds (47th-68th) found a national average expenditure elasticity of approximately 0.55, but this masked substantial heterogeneity, with elasticities ranging from 2.34 for the poorest income groups to 1.57 for the richest, indicating that milk demand is highly income-responsive among low-income households. Disaggregated rural-urban analyses reveal important differences: Patel *et al*. found rural elasticity of approximately 1.82 compared to urban elasticity of 0.96, reflecting higher total milk consumption in rural areas once home production is included, while urban households rely predominantly on purchased milk. Own-price elasticities are generally moderate to elastic (-0.62 to -1.04), suggesting that price increases significantly affect consumption. Studies using

NSS 61st and 68th rounds confirm a structural shift in food budgets from cereals to high-value foods including milk, with dairy's share of food expenditure increasing especially among higher MPCE (monthly per-capita expenditure) classes. The most recent HCES 2023-24 data reinforce these trends, showing continued rise in dairy's share of household food budgets, though only about 45% of Indian households consume milk daily, underscoring persistent disparities by income, region and social group despite rising national production.

Income elasticity estimates for milk in India show a consistent pattern across multiple studies spanning three decades, though magnitudes vary by methodology, time period, and disaggregation level. Early foundational work by Radhakrishna & Ravi (1990) using Linear Expenditure System found elasticities of 1.15 for rural and 1.09 for urban areas, establishing milk as a strongly income-elastic good. Regional analyses reveal substantial spatial heterogeneity: Saxena (2000) reported a national elasticity of 1.96, with rural areas ranging from 1.24 in Punjab to 2.92 in Orissa, and urban areas from 0.99 in Punjab to 1.78 in Bihar, demonstrating that low-consumption states exhibit much higher responsiveness to income growth. More recent demand-system studies using Quadratic Almost Ideal Demand System (QUAIDS) methodology on NSS data show a wide range depending on model specification—from 0.429 (Food Characteristic Demand System, FCDS) to 1.640 (QUAIDS multi-stage) at the all-India level according to Mittal (2006, 2010), while Kumar *et al*. (2011) obtained a national elasticity of approximately 0.55 when milk is embedded within a complete food demand system. Disaggregation by income class reveals the most striking pattern: the NDDB's comprehensive QUAIDS study found expenditure elasticities of 2.342 for the lowest income group declining to 1.566 for the highest income group, with a national average of around 0.55, confirming that milk is a luxury good for the poor but approaches a necessity for wealthier households. Studies by Dastagiri (2004) and Gandhi & Zhang (2010) consistently show rural elasticities above 1.3 and urban elasticities near or above 1.0, reinforcing that milk demand remains highly income-responsive across most of the Indian population, with profound implications for nutrition security as incomes rise.

Livelihoods, poverty and access to food

The dairy sector is a major source of livelihood, directly engaging an estimated 80-100 million rural households, many of them smallholders or landless laborers with limited access to land-based income [26, 18, 27]. Regular milk sales provide a relatively stable cash flow compared with seasonal crop harvests, enabling households to smooth consumption, purchase food staples, invest in healthcare and education and cope with emergencies [25, 28]. For poor households, livestock often function as a "mobile bank," with animals being sold or milk output increased when liquidity is needed, which provides a safety net that reinforces food security [8, 28].

Empirical studies link dairy development to poverty reduction and improved nutrition in multiple contexts. Analyses synthesized by international dairy networks indicate that growth in smallholder dairy production can reduce the incidence and depth of poverty through higher farm incomes, employment generation in processing and marketing, and multiplier effects in local economies [28]. In India, government documents emphasize that the expansion of milk production and cooperatives has contributed to both income security and better household nutrition, particularly for small and marginal farmers [18, 3]. However, distribution of benefits is uneven, and poorer regions or social groups with weaker market linkages may capture fewer gains from dairy growth [8, 9].

From a food-system perspective, dairying is well integrated into mixed crop-livestock systems in much of rural India. Crop residues serve as fodder for cattle and buffalo, while animal dung provides organic manure and, in some regions, household energy, contributing to circular resource flows that support both crop productivity and livestock production [25, 8]. This integration stabilizes household food supplies by diversifying income sources and reducing reliance on a single crop, thereby lowering vulnerability to climatic or market shocks and indirectly supporting food security [25, 8].

Price inflation trends for milk and dairy compared with other animal proteins

Rising food prices, particularly for milk and dairy products, have become a critical constraint on household food security and dietary diversity in India. While milk prices have historically been volatile, recent years have seen persistent inflation that outpaces overall food inflation, squeezing purchasing power among lower-income households. According to the Ministry of Statistics and Programme Implementation, milk and dairy product inflation rates reached 7.72 percent in mid-2025, significantly higher than the 4.38 percent inflation rate for meat and fish products, and the 0.49 percent rate for eggs. The Consumer Price Index (CPI) for milk and milk products has risen from a base index of 188.4 in mid-2023 to 191.1 by mid-2024, reflecting year-on-year increases of 5-7 percent in recent periods. In absolute terms, average retail milk prices across India reached ₹57.15 per liter in 2023, representing a 12 percent annual increase, with subsequent price hikes in several states and by major brands such as Heritage Foods (2-4% increases) and Amul in 2025. The following table illustrates comparative inflation trends and CPI values for dairy versus other animal-source protein foods in India.

Table 2: Comparative CPI and inflation rates for animal-source proteins in India

Food Category	CPI Index (Base 2012=100) as of mid-2025*	Year-on-Year Inflation Rate (%)	Key Driver
Milk and products	188-191	7.72	Feed cost pressures, demand-supply mismatch, climate impacts
Meat and fish	225-236	4.38	Relatively stable production, lower input cost volatility
Egg	183-187	0.49	Efficient production systems, high supply responsiveness
Chicken (subset of meat)	Not separately indexed	Negative to low positive	High productivity gains, feed efficiency, market competition

*Notes: CPI figures are from Government of India's

Ministry of Statistics and Programme Implementation, reported data for May-June 2025. Inflation rates reflect recent year-on-year changes. Meat and fish category includes poultry, mutton and marine products. The "chicken rate paradox" reflects efficiency gains in broiler production that dampen price increases despite broader food inflation. Milk inflation remains elevated due to cost-push factors (animal feed, fodder scarcity), structural supply constraints, and climate-related production shocks. Eggs show minimal inflation due to automation and rapid flock turnover in commercial systems.

These inflation patterns have important implications for nutrition security. Despite milk's recognized nutritional superiority and widespread cultural acceptance, sustained price inflation makes it increasingly unaffordable for low-income households, particularly in rural areas where dairy is seen as an essential nutrient source for children and pregnant women. The contrast with chicken and eggs-which face lower or near-zero inflation due to production efficiencies-suggests that the availability and affordability of dairy may diverge over coming years unless supply-side constraints are addressed and targeted subsidy or distribution programmes are expanded.

Public programmes, school feeding and targeted nutrition

The Indian state increasingly positions milk as a strategic component of nutrition-sensitive social protection. Several school feeding and child-nutrition schemes, including the Mid-Day Meal Scheme (now PM-POSHAN) and Integrated Child Development Services (ICDS), have been expanded or piloted to include liquid milk, milk powder or dairy-based recipes to enhance protein and micronutrient content of meals for children and pregnant or lactating women [1, 29, 30]. Subnational initiatives such as the GiftMilk school milk program similarly seek to improve attendance, classroom concentration and physical growth among disadvantaged children by providing regular servings of milk [29].

Central and state governments also promote milk fortification as a cost-effective means to address micronutrient deficiencies, particularly vitamins A and D [2, 3]. Fortified milk distributed through public channels or sold in the open market can improve dietary intakes among both program beneficiaries and general consumers, provided that coverage, quality control and consumer awareness are adequate [2]. Policy documents from the Press Information Bureau highlight milk's role as a "near complete food" in such initiatives, emphasizing its contribution to protein, calcium and vitamin requirements across life stages [3].

Inequalities and the "milk divide"

Despite macro-level surplus in milk production, access to and consumption of dairy remain highly unequal within India. Data from the National Family Health Survey indicate that only about 45% of households report daily milk consumption, with substantial gaps by wealth quintile, caste, religion and region [1]. Editorial and policy analyses refer to this pattern as a "milk divide," where richer and urban households consume significantly more milk and dairy products, while poorer and marginalized groups remain under-served [9, 31, 32]. Such disparities mirror broader nutrition inequalities and erode the potential of dairy to act as a universal lever for nutrition security [5, 6].

Affordability analyses suggest that a nutritionally adequate diet incorporating recommended amounts of dairy is unaffordable for a majority of rural poor households [20]. High retail prices, weak cold chains and limited market penetration in remote and tribal areas further constrain regular access [9, 31]. To address these barriers, commentators and policy briefs advocate a combination of supply-side measures-such as investments in cooperative dairies and infrastructure in low-production states-and demand-side interventions, including subsidized milk for low-income families, milk coupons and targeted distribution through existing nutrition schemes [9, 31, 32].

Gender, intra-household dynamics and empowerment

Women occupy a central role in India's dairy economy, often bearing primary responsibility for feeding, milking and basic animal health care, as well as participating in cooperative societies and self-help groups [26, 33]. Evaluations of the National Dairy Plan (Phase I) report that interventions focused on women dairy producers-such as women-only producer groups, extension services and training-have enhanced women's control over income from milk sales, decision-making power and access to information [33]. These changes in agency are significant for nutrition, as evidence shows that women's control over resources is positively associated with higher expenditure shares on food, improved child feeding practices and greater diversity in household diets [25, 33].

From an intra-household perspective, increased availability of milk does not automatically translate into equitable consumption, as gender and age hierarchies often determine who receives animal-source foods within the family [8]. Nutrition-sensitive dairy interventions thus need to integrate behavior change communication and gender-transformative approaches to ensure that young children, adolescent girls and pregnant or lactating women-groups with high nutrient requirements-actually consume adequate dairy products [25, 9]. By linking women's economic empowerment in dairying with explicit nutrition goals, programs can generate synergistic improvements in both livelihoods and human development [25, 33].

Climate change and the dairy sector

Climate change introduces significant new risks for India's dairy sector, with implications for both production stability and nutrition security. Rising temperatures and humidity increase heat stress in bovines, which directly suppresses feed intake, milk yield and reproductive performance; studies on buffaloes in India suggest that extreme temperature events can reduce milk output by 10-30 percent in early lactations, with lingering effects over subsequent lactations [34, 35]. Indirect impacts-such as reduced availability and quality of green fodder due to altered rainfall patterns, more frequent droughts and shifts in vegetation-further constrain productivity and raise production costs, particularly in already water-stressed regions [34, 36, 37].

Projections for the northern plains, which account for a substantial share of India's milk production, indicate that climate-induced losses in annual milk output could reach hundreds of thousands of tons by the 2030s, with associated income losses running into billions of rupees for smallholder farmers [34, 36]. Such declines could make it more difficult to meet rising domestic demand and, if not offset

by adaptation measures, may eventually feed through into higher consumer prices and reduced per-capita availability for poorer households [38, 39]. At the same time, the dairy sector is itself a major contributor to agricultural greenhouse-gas emissions through enteric methane and manure management, prompting initiatives such as NDDB's climate-smart dairying program and ongoing carbon-footprint assessments to promote improved feeding, manure management, renewable energy use and other mitigation strategies that can reduce emissions intensity while safeguarding rural livelihoods and milk supplies [40, 41, 42].

Safety, quality and sustainability

The nutritional benefits of dairy depend on product safety and quality. Concerns in India include microbial contamination, adulteration with water or non-milk solids, and chemical residues such as antibiotics or aflatoxins, all of which can undermine consumer confidence and pose health risks [43]. Regulatory frameworks under the Food Safety and Standards Authority of India (FSSAI), along with quality-assurance mechanisms within cooperatives and private dairies, seek to mitigate these risks through standards, testing and certification [43, 18]. Strengthening such systems is essential for ensuring that milk consumed by poorer households-often purchased from informal markets-is safe and nutritionally intact [43].

Environmental sustainability presents another axis of concern, given the contributions of ruminant livestock to greenhouse-gas emissions, land use and water demand [25, 44, 45]. Policy documents emphasize improving productivity per animal, better feed and fodder management, and adoption of climate-smart dairying practices as ways to reduce emissions intensity while sustaining or even increasing milk output [7, 18, 41]. From a nutrition-security perspective, the challenge is to reconcile the recognized value of dairy for vulnerable populations with the need to operate within planetary boundaries, possibly through moderate consumption levels, efficiency gains and complementary investments in diverse plant-based nutrient sources [25, 10, 46].

India's Trade in Dairy Products

Despite being the world's largest milk producer contributing 24% of global milk production, India's participation in international dairy trade remains disproportionately modest, though it has witnessed significant growth in recent years. In FY 2024-25, India's dairy exports surged by an unprecedented 80% to reach $492.9 million, with export volumes climbing to 113,350.4 metric tons a 77.9% increase compared to the previous year. This remarkable growth was driven primarily by butter and clarified butter (ghee), which accounted for approximately 60% of total exports and exhibited 142% growth, with shipments rising from 27,837 tons to 67,565 tons. Ghee exports have been particularly dynamic, growing at a compound annual growth rate (CAGR) of approximately 35% from 2021 to 2026, making India the world's largest ghee exporter with around 37,000 metric tons shipped in 2023. Skimmed milk powder (SMP) constitutes the second-largest export category at 25-27% of total exports, though milk powder shipments declined sharply to 9,700 tons in FY25 compared to the FY22 peak of 49,654 tons. India's primary export destinations include the United Arab Emirates (the largest market for ghee and SMP), Bangladesh (major importer of skimmed milk powder and butter), Saudi Arabia, the United States (growing market for specialty dairy and ethnic community consumption), and Bhutan. Historical data from 2018-19 shows that Turkey emerged as the largest destination for Indian butter and ghee accounting for 24.48% share, followed by Egypt at 20.27%, while Bangladesh dominated milk powder imports with a 39.98% share.

However, India's dairy export share remains a mere 0.25% of the expansive $101 billion global dairy trade, starkly contrasting with its dominant 24% contribution to world milk production. This limited export participation is attributed to multiple structural challenges including high domestic consumption pressure (per capita availability increased from 322 grams/day in 2014-15 to 471 grams/day in 2023-24), stringent international quality standards and sanitary regulations, inadequate cold chain infrastructure for perishable items, trade barriers including high tariffs and quotas imposed by importing countries, and price competitiveness challenges against heavily subsidized producers from New Zealand and the European Union. During the period 2014-2025, dairy exports demonstrated a growth rate of 10.1% per annum while imports grew at 6.3% annually, though India's share in global dairy imports (0.32%) remained higher than its export share, indicating a net import position for certain specialized dairy products. The government has been actively supporting export expansion through initiatives under the National Dairy Development Programme and infrastructure investments, positioning India to leverage its massive production base for greater participation in global dairy markets.

Policy directions and research implications

Emerging policy discourse positions milk as both a nutritional and economic "anchor," arguing that dairy can simultaneously advance rural livelihoods, gender empowerment and human capital formation [18, 3]. To fully harness this potential, scholars and policymakers highlight several priorities: expanding milk provision through existing schemes such as PM-POSHAN and ICDS; scaling up fortified milk distribution; targeting subsidies or coupons to poor and marginalized households; and investing in dairy infrastructure in low-consumption regions [9, 31, 30]. Nutrition education campaigns are also recommended to increase awareness of appropriate quantities, preparation methods and the role of dairy within balanced diets, while discouraging overconsumption among affluent groups that may face rising risks of overweight and non-communicable diseases [9, 31].

Future research needs include longitudinal studies on the causal impact of dairy intake on growth and cognitive outcomes; analyses of the interactions between dairy consumption, gut health and environmental enteric dysfunction; and nuanced evaluations of the environmental trade-offs of different dairy production systems in India [11, 10, 47]. There is also scope for exploring innovative dairy products tailored to local preferences and constraints, such as affordable fortified milk powders or yogurt drinks suitable for distribution in hot climates with limited refrigeration [29, 32]. Overall, milk and dairy products represent powerful but not standalone instruments for enhancing food and nutrition security in India; their greatest potential lies in being embedded within multi-sectoral strategies that also address poverty, sanitation, women's status and broader dietary diversification [4, 5, 18].

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