

# " ANIMAL-BASED OR PLANT-BASED DAIRY FOODS IN THE INDIAN CONTEXT - A REVIEW "

*Review Paper*

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## **Abstract**

*This review paper analyses the impact of the growth of dairy food, both plant- and animal-based, through a food systems approach in the Indian context. The review's primary purpose was to find solutions that will provide a sufficient supply of healthy food to India's growing population while remaining within environmental constraints. In addition, it looked for answers to fundamentals of nutrition, the livelihood of small farmers and the implications of the growth of dairy foods in the Indian set-up. Articles included in this review are identified through conventional keyword searching strategies, published papers' bibliographies, and sustainability-related journal searches.*

*Studies on plant-based dairy foods were found to be either non-existent or sparse, with India as their focal focus and their impact on traditional dairying. No study found a link between livelihood, nutrition, and sustainability within the Indian context having a central theme of plant dairy foods and their relationship with existing dairy industry dynamics.*

*Keywords: Sustainability, Plant Milk, Plant dairy foods, Alternative dairy foods, Nutrition Security, Food Security, Sustainable diets, Environmental emissions.*

## **1 Introduction**

The design and structure of the general food system approach have made more than 2 billion people suffer from malnutrition (FAO, IFAD, UNICEF, 2021). By 2050, food production capacity must expand by at least 50% to keep up with rising demand and the fiercer competition for land, water, and energy (Machovina et al., 2015). The current food systems, particularly dairy, significantly contribute to biodiversity loss, soil erosion, contaminated freshwater, deforestation, and climate change (Machovina et al., 2015). These changes highlight the urgent need for policies and methods to reorient food systems sustainably through alternate food consumption patterns and diminished environmental implications of dietary choices. (Willett et al., 2019). In current food systems, livestock contributes to 13% and 28% of global protein and energy, respectively (Varijakshapanicker et al., 2019).

The Paris Agreement and the Sustainable Development Goals (SDGs), 2, 12, and 13 of the UN Framework Convention on Climate Change (UNFCCC) can be met by strengthening the sustainability of the world's food systems (UN, 2020). However, given the expanding global population and fast-changing dietary trends, improvements must be implemented sustainably (Willett et al., 2019). Therefore, the economic, social, and environmental sustainability pillars must be considered and balanced for sustainable milk production and consumption.

Animal dairy food, i.e., livestock as a food source, is an underwriter of the economic and social lives of the rural inhabitants in India. Dairy farming is the most common and profitable livestock business (Singh et al., 2020; Yadav et al., 2021). The livestock sector accounts for around 6% of GDP, while agriculture

accounts for 25%. For India's smallholder dairy farmers, dairy farming is their primary source of Income (Roy et al., 2021). On average, a farmer has a holding of 2 to 3 cattle producing 10-15 litres of milk daily. After household consumption of 25-40% is available for the market, this milk translates to around 8-10 litres of milk on average. Hence, most of the rural population is connected with rearing animals and dairying. In addition, around 14 million farmers are landless and do not have any land but only livestock on which they depend for household income (Statistics, 2019).

Hence, landless farmers rely on dairying, which is done on a small scale that will give modest returns but regular returns. The dairying sector is one of the essential factors for livelihood and bringing people out of poverty (Madhavan et al., 2020). Another critical aspect of Indian livestock farming is a means of creating value by recycling biomass that cannot be consumed by humans directly. It is one of the most significant aspects of the Indian farmer feeding practices. Generally, cereal straws, groundnut hay, sugarcane tops, cotton or mustard cakes, brans etc., are the crop residues that are the primary livestock feed in Indian conditions (Vigne et al., 2022).

On the other hand, dairy production in India faces many challenges, including low productivity with high greenhouse gas emissions per unit of product, environmental degradation, competition for land, and manure overload in semi-urban areas. In addition, climatic changes cause extreme weather events, such as prolonged droughts or higher temperatures, which require adaptations in agricultural production systems to withstand these changes. As a result, most of the livestock in India is characterised by low productivity. Furthermore, low input–low output dairy farming typical of the Indian dairy sector leads to relatively high emissions of greenhouse gases per kg of product (Haas et al., 2019).

Alternatively, the growth of plant-based dairy foods manufacturing is more environmentally friendly than foods derived from animals. Critical factors for the growth of alternative dairy foods have been the platform of sustainability and environmental commitments (Schiano et al., 2020). In addition, the growth is happening due to the adoption of vegan culture, healthy options, moral grounds, lower Green House Gases (GHG) emissions and prevalence of lactose intolerance (Matt, 2021). Plant-based foods are perceived to offer healthy options. Medical conditions like lactose intolerance, allergy to Cow Milk proteins, or way of life are the key determinants of growth (Silva et al., 2020). Plant-based dairy foods sale has increased as 35.8% of consumers perceived it to be part of a healthy lifestyle while 14.3% of consumers have bought the product from underlining health issues. Other factors for sales are Ethical treatment of animals (10%) and environmental concerns (10.0%). At the same time, 12.4% of consumers like the product's taste (Pritulska et al., 2021).

## **1.1 Purpose of the study**

This current review aims to understand better India's complex and changing dairy environment and the role of plant-based dairy foods in current dairy landscape with focus on nutrition, environmental concerns, and food security by looking at it from a food systems perspective.

## **2 Dairy Landscape**

As per the Department of Animal Husbandry GOI (2021) report, India is the largest producer of milk, reaching the figure of 198.40 million MT in 2019-20 with a growth of 5.68% per year against the World average of 1.43%. India has a large population of 303.76 million bovines (cattle, Buffalo, Mithun and yak). The per-person availability has reached 405 gms/day against the world average of 305 gms/day. Further, the report highlights that small & marginal farmers produce the most milk. Eighty million rural households are dairying, owning 47.34% of farmland, whereas livestock holding is 75.24% of milch animals. Income from the farming of animals increased from 4.3% to 12% between 2003 to 2013 (Department of Animal Husbandry GOI, 2021).

The importance of dairy in India can be judged by the fact that India is the world's largest milk producer and consumer (Varijakshapanicker et al., 2019). In India, 80 million rural households depend upon milking, of which around 80% are landless, small, and marginal farmers. Dairy is an economic activity

that gives wages to a farmer (Shah, 2012). Dairy is only a subsistence living for them. Hence any changes in the character of the Indian dairy industry will have a significant impact (Bhandari & Ravishankar, 2020).

On the economic front, valuation in the dairy chain will reach INR 21,971 (USD 295 billion) by 2024 from the base of INR 11,357 billion (\$151 billion) in the year 2020 with a CAGR of 15.4% from 2021 through 2026 (*Dairy Industry in India 2022 Edition: Market Size and Growth*, 2022). Hence the growth in numbers implies that dairy is vital to the Indian economy. However, on the other hand, India has only 2.3% of arable land to feed the 16.85% of the world population. Due to increasing demand for food, increasing pressure on land, and rising prices of land and water, conventional dairy systems are under immense pressure. As a result, dairy must compete for land with other high-value crops (Ahmad et al., 2019).

At micro levels, Animal dairy is pivotal in daily life by meeting the nutrition required in rural areas and providing seed capital for production commodities. The dairy sector has the most potential for employment as 75-80% of small, marginal, and landless labourers become engaged in the sector with the least unit employment cost (Madhavan et al., 2020). Dairying provides a stable, year-round income, an essential incentive for small farmers. It directly enhances household income by providing high-value output from low-value input and acting as the capital source for future investment. Dairy is one important activity that helps in the socio-economic development in rural areas and helps in sustainable development (Siddiky, 2017).

### 3 Plant-based dairy foods

India is the world's most significant producer and consumer of bovine milk; therefore, the demand for plant-based dairy products still is low compared to animal-based Milk (Basu, 2022). Animal-based dairy is the biggest agri-businesses in India, with a 4% share in the economy. The animal-based dairy industry has grown 12% in the last five years, with value-added products driving market growth (Manohar, 2021). However, despite its modest market, plant-based dairy is becoming increasingly popular in the Indian context. Soy, almond and oat milk are just a few plant-based milks that have made promising inroads with Indian consumers. Estimated at \$21 million Vs the animal-based dairy industry at \$140 billion, plant-based dairy in India is projected to grow at a CAGR of 20.7% to reach \$63.9 million by 2024 (GFI India & Ipsos, 2020).

India has a fantastic diversity of milk sources. From cow to buffalo, milk from sheep, goat and camel, milk from Yaks in Himalayas and Mithun, and even donkey Milk. In addition, several plant-based milks have a long history of consumption in India. Coconut milk is very popular in India and has been used for ages. Soy milk also is prevalent in many parts of India. Another milk which has real potential in the Indian landscape is milk derived from Cashew. Rather than a threat, producing plant-based and animal-based milk from multiple sources may be seen as an opportunity (Doctor, 2022)

According to the Good Food Institute India study, plant-based milk users in India will continue using both plant- and animal-based milk in the near future. Users of plant-based Milk state that they will keep drinking both plant- and animal-derived milk in the future. In comparison to 44 per cent of the same users who use animal-derived milk, 69 per cent of plant-based dairy consumers said they are most likely to increase their consumption of plant-based milk in the future. Ninety per cent of plant-based users have also consumed animal-based dairy milk in the past 12 months. With plant-based milk emerging as a new vertical of growth for the packaged milk category, this demonstrates the possibility for both types to coexist and flourish for different reasons(GFI India & Ipsos, 2020).

Consumers in India give plant-based milk high marks for distinctive qualities like sustainability and lactose intolerance while giving animal-derived milk higher marks for taste, price, and versatility, demonstrating that both categories are individually appealing. Sixty-nine per cent of people who drink plant-based milk say they intend to increase their intake in the future. Fast-tracking the adoption of plant-based dairy products in India and securing their position as a novel and exciting opportunity for the

packaged milk category as a whole can be accomplished by improving the product's flavour and adaptability as well as accessibility, i.e., availability and affordability (GFI India & Ipsos, 2020).

## 4 Nutrition

India can feed its population by supplying all essential macro & micronutrition for food security and adequate nutrition (Swaminathan et al., 2012). Nevertheless, still, India has the highest proportion of stunted (31 per cent) and wasted children (51 per cent) and under-five deaths (16 per cent). India is also the home to the largest undernourished people globally (24 per cent of the world population) (FAO, 2021). Indian diets derive almost 60 % of their protein from cereals with relatively low digestibility and quality (Swaminathan et al., 2012). This low quality varies between 4% and 26% in different age groups and urban and rural locations (Minocha et al., 2017). Therefore, there is a significant risk of low-quality protein intake in India.

As discussed above, nutrient consumption is predominantly cereal centric in India. The agricultural policy in India drives food production, availability, and access to food. This policy has placed a significant thrust on food grain production to meet the requirements of the staple diet. Nutrition diversity is only possible if food diversity is in place with crop diversification. Indian nutrition mapping shows low levels but high inequality in nutrition. Agriculture that supports the vast majority did not become part of the economic success; hence we see a decline in nutritional quality in rural India (Ramadas et al., 2020).

On the other hand, milk consumption in India is increasing, with the primary drivers of the demand being the increasing purchasing power of the consumer, being the cheapest source of animal protein to a large segment of the population. The demand is also pushed by ample availability of Milk & Milk products, value addition in the offerings, and organised retail chain growth; these factors drive the growth in the Indian dairy sector. As per the Consumer Expenditure Survey, 78% of the rural population and 85% of the urban population reported milk & milk products (Department of Animal Husbandary GOI, 2021).

## 5 Environmental Impacts

A significant challenge for the policymaker in the coming years will be meeting the population's requirements for nutrition and reducing environmental impact. Agriculture is grown on 38% of the earth's surface and uses 70% of the freshwater, of which 35% is for animal feed. If we combine the land for grazing and feed production, 75% of the land is used to raise livestock (Aschemann-Witzel et al., 2020). As a result, the agriculture animal sector is the largest producer of Green House Gas emissions. It is mainly due to the land being used for feed production and the methane produced by animals. Animal agricultural emissions are 14.5% of total GHG emissions (Lazarus et al., 2021). Furthermore, earth ecosystems are mainly influenced by agricultural production. Without interventions, the food system impact on the earth's ecosystem could increase by 50–90% (Aschemann-Witzel et al., 2020).

In terms of emissions, methane from cows and other livestock contributes the most to emissions. An important consideration is how much land our overall farming requirements take up. When significant forest areas are used for grazing and cropland, there is a clear link between our land use and rising global emissions. The food supply chain has different stages of the cycle till it reaches the consumer; different stages impact the emission. Across all food supply chain management, the land use and farm stages account for 80% of GHG emissions. Globally, the food supply chain emits 13.7 billion metric tons of carbon dioxide equivalents (CO<sub>2</sub>e) yearly (Data, 2021).

In addition, various studies have also highlighted that net greenhouse gas generation is most significant when grassland is converted to pastures combining trees, forage, and livestock. Land maintained for livestock grazing has lower greenhouse gas emissions than the same land converted for crop production. Furthermore, globally more than half (57%) of the 2.5 billion hectares of land used for producing forage

is unsuitable for food production. 14% of the feed consumed by livestock is edible by humans; the remaining 86%, including by-products, crop residues, and grasses or fodder, is converted into human food.

Another dimension is freshwater usage, which is the biggest issue facing policymakers. Freshwater is a scarce commodity whereby 4 billion of the global population meet a water shortage. Large amounts of water are consumed by agriculture (86% of freshwater goes for food production) to produce feed and food. Livestock consumes 8% of the global water supply, with the most feed. The water footprint in dairy comprises Feed 98%, drinking 1.1%, service water 0.8% and feed mixing water 0.03% of the total WF. Hence most extensive waterfront is taken by the animal's feed (Irfan et al., 2015).

If we look at India's total net sown area is about 140 million ha, and nearly half of it (68.4 million ha) is irrigated. India's Green Revolution's promotion of high-yielding varieties of seeds and fertilisers did solve food-grain shortages. However, its aftereffects are now visible in the form of degraded land, soil, and water quality. In addition, farmers' incomes are declining due to a high external inputs. Between 2011-12 and 2015-16, the annual growth rate for all farmers' income declined from 5.52 per cent to 1.36 per cent. Moreover, the agro-ecosystems of the Indo-Gangetic plains, which have the most fertile soils in India and cover about 13 per cent of the total geographical area, are undergoing severe land degradation due to soil erosion & nutrient depletion (Gupta, Niti, Shanal Pradhan, Abhishek Jain, 2021).

According to India's Desertification and Land Degradation Atlas, 96.4 million ha, almost 30 per cent of the country's total geographical area, is undergoing land degradation/ desertification (Space Applications Centre, 2016). Another serious threat to Indian agriculture is mainly rainfed and fundamentally dependent on climatic stability. With the projected 1.5-degree Celsius increase in the planet's average atmospheric temperature and the more significant variability in summer monsoon precipitation, risks to food security, livelihoods, water supply, and human well-being are bound to increase (Gupta, Niti, Shanal Pradhan, Abhishek Jain, 2021).

## 6 Sustainability Context

Sustainability in diets is "Sustainable diets are those diets with low environmental impacts which contribute to food and nutrition security and healthy life for present and future generations" (Burlingame & Dernini, 2012). These diets are achievable per Smith Edge (2020) if we collaborate and build consensus to provide nutrient-dense, affordable, culturally appropriate, and respect for the environment. Here the goal is to find sustainable solutions for foods that will produce more food with less land, less water, and less labour which is the driver of today's food value chain (Smith Edge, 2020).

The critical areas for sustainable development in food are nutrition, economics, society, and the environment (Burlingame & Dernini, 2012). Further, sustainable diets need to meet the four parameters for acceptance as future diets. However, few small food groups satisfy all four domains of sustainability, i.e., nutrition, economics, society, and the environment. Therefore, eating habits, food systems, health, environmental and social issues, the use of antibiotics, and animal welfare are crucial sustainability parameters that must be considered while arguing for diet substitution. (Roos et al., 2018).

There are no specific principles for sustainable diets, but we need to look from the context we are seeking, which country we are looking and focus on which demographic base. Smith (2020) states that no single solution will address our food system sustainability issues without consequences in either direction. In terms of milk & milk products from the animal source, they provide more nutrients than calories and meet the nutrient density test. In addition, they are one of the most affordable food groups but whether they fit into sustainability diet parameters is a question which needs to be explored from various angles of sustainability parameters.

Two competing perspectives continue the argument of sustainability for animal milk. The first is that the production of dairy foods now uses less land, produces fewer greenhouse gas emissions, and uses less water due to better techniques. Nevertheless, animal milk still has a more significant environmental impact per mass than plant-based dairy substitutes. The environmental effects of dairy products are two

to three times greater than those of plant-based milk (Roos et al., 2018). The second point pertains to a benefit provided by grazing animals to semi-natural pastures that support biodiversity preservation. Ruminants also contribute to transforming low-value biomass into nutrient-dense foods for people, a factor that has not been well considered in traditional Life cycle assessment (LCA) research.

In one study, The EAT-Lancet Commission for Food, Planet and Health, a group of 20 leading scientists from throughout the world in the fields of nutrition, health, agriculture, food policy, and sustainability, were appointed to address the question of how we give all humans a healthy diet without depleting the planet's resources. The report from the group came out with the findings of adopting a healthy planetary diet; a flexitarian diet mainly plant-based with limited amounts of fish, meat, and dairy foods (Willett et al., 2019). This study corroborates the earlier study where flexibility in diets with the context we seek looks more practical than focusing purely on an environmental basis. This point is further strengthened by a meta-analysis of various studies, which points to the fact that the same environmental impact can be achieved as that of the vegan diet without excluding the meat and dairy food groups, but rather by reducing them substantially (Chai et al., 2019).

## 7 Discussion & Findings

The environmental impact of producing milk using animals is far more significant than other food types. Only a small part of the feed consumed by livestock is converted into muscle tissue, such as meat, eggs, or milk because most feed is consumed by the animal's metabolic processes, bone formation, and other purposes. Compared to plant-based milk substitutes for direct human consumption, this results in a significantly higher demand for land to produce the same volume of milk. This has only lately opened the door for non-dairy alternatives to enter the market, and the non-dairy beverage industry—which is primarily based on soy, almond, and other vegan sources—is currently attempting to leave its mark (Paul et al., 2020).

In addition to the sustainability of production, food security and climate change mitigation must be addressed simultaneously for sustainable milk production and consumption. If we see the Indian context, socio-economic sustainability is crucial since milk production and consumption offer a means of enhancing human nutrition and health as well as the chance for economic opportunity and an improvement in subsistence farmers' standard of living (Adesogan & Dahl, 2020). Furthermore, milk and dairy products add diversity to the diet and significantly help at-risk populations, particularly children, pregnant women, and the elderly, satisfy their needs for high-quality protein, calcium, magnesium, selenium, riboflavin, vitamin B12, and pantothenic acid (vitamin B5) (Adesogan & Dahl, 2020).

The Indian dairy sector has a unique issue; on one side, the nutrition challenges must be met, while on the other side, animal food consumption needs a shift to more sustainable ways. The third part of the problem needs small & marginal farmers to sustain their livelihoods by growing dairy animals and guaranteeing farm-level food security. As a result, averting runaway climate change necessitates deliberately altering lifestyles through means that filter out extremely carbon-intensive consumption options while driving innovation toward items and activities that better satisfy human needs while also being regenerative.

India needs to manage the transformation so that the agriculture sector realises the potential to reduce poverty, increase access to nutrition and simultaneously work on improving income at grassroots levels. It has been observed that an increase in the food itself will not help unless the same is accompanied by cash in hand. No data has substantiated that an increase in the agri-food chain also helps to improve the nutrition base (Gillespie et al., 2019). The dietary patterns are the trade-off between the energy requirement, water footprint, and GHG emissions, which need to be considered while considering diets and switching between them (Green et al., 2018).

## 1.2 Findings

During the review, it was observed that there are non-existent studies on plant dairy food considering India as a central point and its effect on traditional dairying in India. No study found a link between livelihood, nutrition, and sustainability within the Indian context having a central theme of plant dairy foods and their relationship with existing dairy industry dynamics. As the dairy substitutes grow in scope, acceptance, and value in the Indian market, will they impact traditional dairy? If yes, what will be the impact and the way forward? These all remain unanswered on traditional dairy processing in India and the measured impacts on the income of small and marginal farmers.

Furthermore, the review was unable to provide information on how the growth of plant-based foods would improve the population's nutritional status. In addition, the index for measuring nutrient density related to the climate impact of different foods still needs to be evaluated as different studies point to different results in measuring the nutrient density in relation to Global warming potential.

Looking more into food technology advancements that offer a solution to the sociological, nutritional, and other issues related to animal-based goods is essential. The literature assessment shows that further study is needed to examine the effects of animal-based agriculture on important metrics other than GHG emissions and water footprints concerning environmental research relating to the replacement of animal meals. These measurements might include soil health, biodiversity loss, and nutrient contamination. In addition, it is necessary to do detailed evaluations of the benefits of dairy substitution for enhancing food security in underdeveloped nations.

## 8 Future Direction

Sustainable livestock systems are essential to food security, economic and environmental management, and sociocultural needs, as stated in the United Nation's Sustainable Development Goals. Efficient livestock production management offers the most significant potential to reduce greenhouse gas emissions from agriculture. While livestock systems generally contribute to sustainability, poorly managed systems lead to adverse environmental effects. Therefore, the livestock system need not be looked at from the prism of the environment but to be evaluated as a critical enabler for food and nutritional security, affordably and safely. Therefore, we need to look at livestock's contribution to sustainability goals by using uncultivable land for food production and converting energy and protein sources humans cannot use into highly nutritious animal-sourced food (Varijakshapanicker et al., 2019).

The benefits of alternative dairy products are restricted to the setting in which they are being researched and the context in which they are being defined. Therefore, more modelling studies are needed to explore various factors in diverse dietary contexts for customers, such as dairy products or various plant-based alternatives or combinations. As a result, additional research is needed to understand better-eating patterns to achieve a less environmentally harmful and healthier diet. (Roos et al., 2018).

We need to make significant changes in our lifestyles. Plant-based dairy, one of the keys to sustainability discussion, must be palatable, safe, nutritious, and affordable. Enabling sustainable lifestyles will require a broad shift in the values that underscore a shift in consumption and eating patterns for a large population segment. This, in turn, requires strategies that span individual and lifestyle domains.

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