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DAIRY FARMING IN INDIA: A COMPREHENSIVE REVIEW OF PRODUCTION SYSTEMS, INPUT CHALLENGES, AND SUSTAINABILITY MEASURES

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ABSTRACT

Dairy farming has been a pillar of rural livelihoods in India for decades, contributing significantly to income, nutrition, and employment. With the largest population of milk consumers and producers worldwide, India's dairy landscape varies from smallholder mixed-farming systems to peri-urban commercial dairies. The industry has experienced vigorous growth, with milk production increasing steadily at an average annual rate of 4.2% since 2000. Notwithstanding the impressive production figures, the Indian dairy industry is still plagued by several challenges. These include low per-animal productivity, restricted access to quality feed and fodder, high cost of production, disease prevalence, and weak veterinary infrastructure. The dominance of the unorganized sector also inhibits efficiency and quality control. The present paper gives an in-depth analysis of India's dairy production systems, identifies input-related problems preventing optimal output, and discusses ecologically sustainable farming practices to increase productivity while maintaining ecological balance. The review highlights the need for policy reforms, enhanced extension services, uptake of new technologies, and increased support to small-scale dairy farmers to attain a resilient and sustainable dairy industry.

Keywords: *- Dairy farming, milk production, sustainability farming etc.*

INTRODUCTION

Dairy farming has significantly contributed to the rural economy. Milk has emerged as a significant source of money generation in rural India. Dairy products, including milk, are essential elements of contemporary diets. India is the preeminent global producer and consumer of milk, with the biggest dairy herd, which consists of water buffalo and both indigenous and crossbred cattle. Since 2000, the annual rise in milk production and consumption has consistently averaged 4.2 percent, and India has also become a minor net exporter of dairy products. According to the 19th livestock census, India has the highest livestock population globally, ranking first in buffalo (108.7 million) and second in cattle (190.9 million). It constitutes approximately one-fourth of the global bovine population. India attained an accomplishment of around 155.5 million tons during 2015-16, with a per capita availability of 337 grams per day. Dairy farming serves as a primary source of income for well over 100 million individuals. A significant percentage of small-scale livestock keepers lack access to land, and the prevalence of rural landless families are expected to rise due to the continued fragmentation of land holdings. For smallholder and landless farmers, cattle are increasingly vital for revenue generation. These initiatives have enhanced the food basket, nutritional security, and family income of farmers, significantly contributing to the creation of gainful employment in rural regions.

The current status of dairy farming in India

Livestock production and agriculture are fundamentally interconnected, with one relying on the other, and both are essential for comprehensive food security. Since 1970, India's milk output has increased by around 4% annually, and in 2006, India emerged as the world's largest milk producer. At the national level, indigenous buffaloes contribute about 36% of milk production, while crossbred cattle contribute 26%. Indigenous cattle account for 12% of the nation's total milk output, while nondescript cattle contribute 9%, and nondescript buffaloes provide 13%. Annually, buffalo milk output increases by 4%, while cow milk production climbs by 1.2%. India is the leading worldwide producer of milk, achieving around 155.5 million tons in 2015-16. In the years 2015–16, the per capita availability of milk reached 337 grams per day, surpassing the global average of 299 grams per day in 2015. Despite India's status as the leading milk producer, the average yearly milk output from cows and buffalo is about 1214 kg, compared to the global average of 2104 kg per lactation. A

substantial population of milk-producing animals exists; nevertheless, the average milk yield per animal is significantly lower compared to other nations. The animal husbandry and dairy industry in India significantly contributes to the national economy and the socio-economic growth of the country. Estimates from the Central Statistics Office (CSO) indicate that the production value of the livestock industry at current prices was around 591,691 crore during 2015–16, constituting roughly 28.5% of the output value from the agricultural and allied sectors. At constant prices, the output value from livestock constitutes around 29% of the entire agricultural and allied industry production value. The Indian dairy sector has significantly progressed from a milk production of 17 million tons in 1951 to 187.7 million tons in 2019. Despite India holding the top position in milk production, the average yield rate per cow is significantly lower than that of other nations. During the year 2015-16, the average milk output of indigenous buffalo and cattle was 5.76 kg/day and 3.41 kg/day, respectively. A breeding policy must be developed to address this concern [5].

PRODUCTION SYSTEM IN DAIRY FARMING

In underdeveloped nations, small-scale production accounts for 80–90% of typical milk output. Due to minimal input, animal production is destitute. Emerging nations typically employ the following manufacturing systems:

Smallholder dairying in rural areas: It is made up of three cows or buffalos and is a component of the mixed farming system. On average, they produce three liters of milk. Animals consume grasses and crops, and their dung serves as organic fertilizer for the crops. Only when it is feasible, such as when someone keeps one or two animals on their property, is additional feeding carried out.

Commercial dairying in rural areas: The recently established dairy business has encouraged some forward-thinking farmers to invest in milk production. These farmers still make up fewer than 1% of all dairy farms in the nation, though. The average animal produces 10 liters of milk every day. The system is comparable to one that is focused on the market.

Agropastoral dairying and pastoral: Milk is a significant substitute in this land-based system. However, animals eat very few crops and mostly graze meadows and groundwater, much like nomadic humans. The production of dairy products is limited and often intended for individual consumption. (entrance to the manufacture and final product of dairy).

Peri-urban dairying without land: This tiny, market-driven manufacturing system is found in urban areas or near the marketplace. Three mature female buffaloes, two female followers, and a male calf constitute the majority of the five buffaloes. Although they rely on purchased inputs (feed) for their production, they struggle with waste disposal and feed availability. This industry has grown significantly in large cities in recent decades to meet the needs of the human dairy industry.

System of peri-urban production: Major cities surround this commercial-scale facility. The usual herd size is between 10 and 200 animals, with 90% of them being buffaloes and 10% being cows. These entities employ both paid workers and family members. They use several routes to transport the milk to the market [6].

Dairy farming production: Indian scenario

India is the country that produces the most milk in the world. Several years ago, this was not the situation at all. Historically, the nation had a shortage of milk and had to import milk from other nations to meet the demands of its expanding population. India produces over 20% of the world's milk, followed by the US, China, Pakistan, and Brazil. During the 1950s and 1960s, India was highly reliant on milk imports. However, in 1965, the Indian government made the decision to form a National Dairy Development Board to boost India's dairy industry. The country's goal was to increase milk production beginning in the 1970s, which resulted in the introduction of Operation Flood. In 1998, India surpassed the United States to become the greatest milk producer in the world. Over the period of 1991-2019, the availability of milk per capita in India more than quadrupled, while the country's milk output increased at a compound annual growth rate of 4%.

In 1991, the availability of per capita drugs in India was 178 grams per day, but by 2018, the availability of per capita drugs in India had increased to 411 grams per day. Similarly, the availability of the substance per person in the world in 2018 was 302 grams per day.

Table 1: illustrates the per capita availability and production of milk in India.

YEAR	PRODUCTION (million tonnes)	Per capita Availability (gms/Day)
2010-2011	281	121.8
2011-2012	290	127.9
2012-2013	299	132.4
2013-2014	307	137.7
2014-2015	322	146.3
2015-2016	337	155.5
2016-2017	355	165.4
2017-2018	375	176.3
2018-2019	394	187.7
2019-2020	198.4	407
2020-2021	210.0	427

India's milk output was 55.6 million tons in 1991 and increased to 187.7 million tons in 2018. The compound annual growth rate (CAGR) of milk production in India from 1991 to 2018 was 4%. The Secretary of the Department of Animal Husbandry and Dairying under the Ministry of Fisheries, Animal Husbandry, and Dairy has described Operation Flood as the most ambitious dairy development initiative globally, serving as a catalyst for the nation's advancement in milk production [10].

SUSTAINABILITY MEASURES

Sustainable dairy farming in India is a novel concept that envisions the efficient and appropriate utilization of resources without resorting to overexploitation. It is crucial to

recognize that the economic, environmental, and social sustainability of an agricultural system is contingent upon its effective administration.

It is important to take into account the structure of the farm and the local environment when selecting animal varieties for a farm. Implement an efficient herd health and disease management program to prevent the introduction of disease. Prevent the presence of chemical residues in milk by utilizing veterinary medications and prescribed chemicals. Ensure that the milking process does not injure cows or introduce contamination. After milking activities, ensure that milk is handled appropriately. Provide quality and secure products to feed and water animals in adequate quantities. Ensure the traceability of feedstuffs purchased from the farm and regulate the conditions of feed storage. Guarantee that all animals are unaffected by starvation, thirst, malnutrition, discomfort, pain, injury, disease, fear, distress, and normal animal behaviour.

Sustainability measures		**References**
Environmental sustainability	• Prevent pollution, soil erosion, and environmental degradation by ensuring that soil fertility is maintained. • Efficiently oversee and optimize water consumption. • Preserve or improve the biological diversity of the farm. • Maintain or enhance the quality of the oxygen. • Reduce the negative effects of climate change and the global environment. • Ensuring that energy resources are selected and utilized appropriately. • Utilize crop by-products to the greatest extent feasible on the farm. • Recycle the farm's refuse.	[11][12]
Economic	• Guarantee the safety, quality, and transparency of	***[13][14][15][16]***

Sustainability	the products throughout the production process and storage facilities. • To pay staff and make suitable investments, assess the agricultural income's long-term stability. • Attempt to optimize benefits by selecting efficient trading channels and becoming organized. • To enhance farm income and mitigate risks associated with market price fluctuations, it is recommended that the farm diversify into additional farming activities or potential non-farming activities, as appropriate.	
Social Sustainability	• Foster a congenial and agreeable workplace, devoid of any form of discrimination and disciplinary measures. • Farmworkers and their families, if relevant, possess access to adequate sanitation, housing, and transportation facilities and services. • Verify that employees' working hours adhere to national and local regulations. Overtime conducted during the peak season is permissible but appropriately remunerated. • Guarantee that employee compensation and benefits adhere at a minimum to local and national regulations. • Guarantee that working conditions adhere to guidelines concerning occupational health and safety.	***[17]***

CHALLENGES IN DAIRY FARMING

India now has a 28.9 percent concentrate deficit, an 11.24 percent green fodder shortfall, and a 23.4 percent dry fodder shortage. Only 5% of the nation's arable land is now used to generate feed. The 19th livestock census and statistics from the National Agricultural Technology Program (NATP) showed that India is experiencing a scarcity of fodder and that the quality of the feed that is now available is subpar and does not satisfy the requirements for animal nutrition. The growing need for high-quality feed and fodder to satisfy the nutritional needs of milking cows is a result of the growing popularity of high-breed animals. Unproductive dairy cows are outnumbering productive dairy animals in the competition for feed and fodder. Due to industrial expansion, grazing grounds have been drastically decreasing recently, which has led to a scarcity of feed and fodder. Due to their inability to buy enough feed and fodder, small and marginal farmers and agricultural laborers involved in dairy farming continue to underfeed their animals [18]. Feed expenses can make up as much as 70% of overall expenditures in typical dairy production systems. Consequently, high-cost feeding has an impact on the profitability of dairy production.

Absence of germplasm with high yields:

The main issue facing Indian farmers is the low production and output of dairy cows. India is the world's greatest producer of milk and has a sizable cattle population, yet the productivity of dairy cows has been incredibly low, making this essential resource a burden for the impoverished. Over 60% of rural families keep large ruminants, primarily for milk production and partially for draught from bullocks [19]. Nonetheless, Indian dairy cows produce a remarkably low amount of milk on average.

High milk production costs:

For milk to provide a healthy profit in India, the cost of manufacturing must be lowered. The low average milk yield of Indian cattle—987 kg/year rather than 6273 kg/year in Denmark, 5289 kg/year in France, 5938 kg/year in Canada, 5462 kg/year in the United Kingdom, 7038 kg/year in the United States, and 11,000 kg/year in Israel—is the primary cause of the high cost of milk production [20]. Consequently, farmers in other nations pay far less than those in India. Therefore, appropriate feed, water management, and housing, along with excellent genetics, have contributed to this high yield.

India's unorganized dairy industry:

The primary characteristic of the dairy business in India is its continued lack of organization. The organized sector in India only handles 18–20% of the country's total milk output. The contemporary processing infrastructure has yet to include the unorganized sector. India produces and consumes more milk than any other country in the world, yet its per capita consumption is still far behind that of wealthy nations. In the dairy industry, India does not actively import or export. Transportation and procurement are the dairy industry's biggest problems. The most important aspect of the dairy sector is the acquisition of fresh milk. The perishable nature of milk restricts its availability to a 200-kilometer radius. Supply chain issues and cold storage impact India's dairy business [21].

The adoption of technology by dairy farmers in India is inadequate.

Technologies for feeding cattle, such as silage, hay production, and urea-molasses treatment, have previously been shown to produce high-yielding fodder types. Regretfully, many farmers in the majority of states have not embraced this technology at all. An average of 500 million tons of agricultural waste is produced annually in India, according to a report by the Ministry of New and Renewable Energy (MNRE). The same research indicates that both home and commercial settings utilize the majority of this crop residue as fuel and feed. Nevertheless, 140 million tons remain in excess, of which 92 million tons are burnt annually and may be utilized as animal feed.

The most practical and economical way to deliver enhanced genetics to farmers' doorsteps is through artificial insemination (AI). India first used artificial insemination (AI) in 1970. Bovine AI penetration is only 30%, with some states having 1% coverage and others 71%. As a result, 65 percent of animals are still bred spontaneously, either because of the lack of services at the farmers' doorstep, the ineffectiveness of frozen semen, or the lack of a qualified AI specialist [22].

High disease-related financial losses are a concern for dairy farmers.

Animal illnesses place a heavy financial strain on farmers. These animals are now more vulnerable to various illnesses, including exotic ones, as a result of the improved quality of germplasm that the cross-breeding program has produced. Inadequate vaccination coverage consistently results in economic losses from a wide range of animal diseases. It's difficult to

estimate the losses caused by various diseases because not all illnesses are documented. Hemorrhagic Septicemia (HS), Foot and Mouth Disease (FMD), Brucellosis, and Peste des Petits Ruminants (PPR) were estimated to cause average yearly economic losses of Rs. 5255 crores in 2014, Rs. 20000 crores in 2016, Rs. 20400 crores in 2015, and Rs. 2417 crores in 2016, based on the direct losses from reported diseases. Estimates suggest that farmers in India lose more than 50,000 crores annually due to illnesses that vaccination could completely prevent. Due to non-reporting of diseases, subpar vaccines, ineffective vaccination, livestock farmers' lack of education, etc., the Indian government and state governments spend an equal amount of money on vaccination against these diseases, resulting in a loss of almost one lakh crore rupees.

Insufficient veterinary care in the dairy industry

The lack of proper infrastructure facilities is hurting the dairy industry in India. To ensure excellent veterinary health care, the National Commission on Agriculture (NCA)-1976 advised that one veterinary institution be constructed for every 5,000 cattle units (**one cattle unit = 1 cow, 1 buffalo, 10 sheep, 10 goats, 5 piglets, and 100 poultry**). India has 67,651 veterinarians, but there is a need for 110,000 to 120,000 more, according to VCI. As a result of this shortcoming, farmers received inadequate and subpar veterinary care. India began using artificial insemination (AI) as a reproductive technology around 1970 to enhance milk output and cow breeds [23]. However, the average conception rate by AI has not surpassed 30–40% at the field level over the past 50 years due to several limitations.

Poor extension services

The delivery of livestock services to farmers consists of three parts: teaching livestock producers, providing technical inputs, and offering technical services to animals. To deliver animal health services, such as vaccination, deworming, breeding, and illness management, technological inputs, such as vaccines, medications, semen, AI guns, syringes, and needles, must be made available. Livestock farmers must rely on veterinarians or para-vets to provide the aforementioned services and, to a certain degree, technological contributions. Thirdly, livestock producers must get education on various topics related to managing animal husbandry, including breeding, disease control, immunization, and nutrition. Unfortunately, this aspect is often neglected. Extension services must concentrate on increasing farmers'

competencies in addition to transferring technology and bolstering other infrastructure and support services [23].

CONCLUSIONS

We draw the conclusion that, supporting millions of people and serving as a main source of nutrition, dairy farming is an essential part of the rural economy in India. Particularly in view of initiatives like Operation Flood, which made India the top milk producer in the world, significant progress has been made in increasing milk output over the years. Notwithstanding these developments, many systematic problems continue to occur, including low milk yields, a lack of modern breeding and extension services, a lack of feed and fodder, high production costs, and poor veterinary infrastructure.

The lack of organization in the dairy sector as well as limited access to premium inputs and modern technologies has limited the potential of smallholder farmers. Furthermore, land-use demands, disease outbreaks, and climate change pose a significant threat to the sustainability of this sector. To guarantee long-term development and resilience, adoption of sustainable practices, enhancement of genetic potential by scientific breeding, improvement of veterinary and extension services, and building of efficient supply chains are all absolutely vital. By stressing social inclusion, environmental sustainability, and economic viability, India's dairy sector can satisfy home demand and help world food security. Ultimately, dairy farming in India has to evolve from a subsistence activity into a disciplined, creative business that helps rural areas while maintaining the natural balance.

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