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Economic sustainability of livestock production systems in Haryana: An indicators based assessment

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Abstract
Economic sustainability assessment in livestock production systems is essential for optimizing profitability, enhancing resource efficiency, managing risks, informing policy development, meeting consumer expectations, and advancing overall agricultural sustainability goals. This study was carried out in three districts of Haryana state to assess the economic sustainability of livestock production systems using ten indicators (Farm income, Efficiency, Per capita availability, Livestock productivity, Livestock production, Productive livestock, Feed productivity, Input self sufficiency, Savings and investments and Marketed surplus). A total of 120 dairy farmers was interviewed by visiting personally. Economic sustainability was favoured by per capita availability marketed surplus. However there appear poor sustainability in terms of farm income, livestock productivity, livestock production, input self sufficiency savings and investments, marketed surplus indicators and partially in term of feed productivity. Further ways and means to improve productivity of livestock, reducing the cost of production, enhancing credit flow, improving self-sufficiency of production systems and improving of feed productivity are suggested.

Keywords: Livestock production systems, indicators, sustainability assessment, Haryana

Introduction

The livestock sector is a pillar of the global food system and a contributor to poverty reduction, food security and agricultural development (World bank, 2021) [36]. FAO estimates that livestock sustains the livelihoods and food and nutrition security of about 1.3 billion people worldwide, accounting for 40% of the value of agricultural output worldwide. Increasing incomes, changing diets, and population growth have led to increased demand and made the livestock sector one of the fastest growing agricultural sub-sectors in middle- and low-income countries (ibid). Furthermore, these advancements and the rise in food production shouldn't come at the expense of the ability of future generations to feed themselves (WCED, 1987) [31]. Production has to rise by 70%, especially in the livestock industry, to feed this larger, richer, and more urban population (FAO, 2009) [12]. Moreover, these advancements and the rise in food production shouldn't come at the price of the ability of future generations to feed themselves (WCED, 1987) [37]. The long-term viability of livestock systems is now being questioned owing to a variety of reasons (Rigby *et al*., 2001; ten Napel *et al*., 2011 van Calker, 2005) [30, 34, 35]

Sustainable livestock production encompasses practices that aim to meet the needs of raising animals for food while minimizing negative environmental impacts (FA0, 2023) [14]. Broadly, the concept of sustainable development combines environmental goals, maintaining biodiversity with economic goals and the social goals all of which have to be pursued simultaneously. Further the economic sustainability assessment is essential to assess the long ability of the livestock units to survive in the rapidly changing economic and market conditions.

In Haryana, animal husbandry is becoming a more vital source of income for the rural populace due to dwindling land holdings, poverty, and population growth. So

sustainability of livestock production system is vital for ensuring livelihood and nutritional security to a large number of rural poor. Till now no study has been conducted in Haryana to assess sustainability of livestock production system. Efforts to evaluate sustainability offer important insights into the strengths and weaknesses of livestock production systems, providing valuable guidance for strategic development within the state. This assessment will help determine the economic viability of livestock enterprises for future generations, ensuring informed decision-making and sustainable agricultural practices aligned with long-term economic and environmental goals.

Materials and Methods

The study was conducted in three districts (Sonipat, Rohtak and Jhajjar) of Haryana state. From each district two block were selected randomly. Two villages were then randomly chosen from each of the two blocks of district using simple lottery method. The selected villages were Chamaria, Garhi Sampla from Rohtak district, Sarai Aurangabad and Mangawas from Jhajjar district and Bhainswal Kalan Bawala, Ridhad from Sonipat district. A list of farmers involved in dairy farming in each village was prepared. The respondents were then randomly selected using simple lottery method. Twenty dairy farmers were chosen from each selected village thus constituting a sample size of 120.

Ten indicators were selected for assessment of economic sustainability of livestock production systems. These were: Farm income, Efficiency, Per capita availability, Livestock productivity, Livestock production, Productive livestock, feed productivity, input self sufficiency, marketed surplus and Savings and investments). Measurement of indicators is documented in Table 1.

Table 1: Operationalisation of Economic Sustainability Assessment Indicators

Sr. no.	Indicators	Operationalisation
1.	Farm income	Perceived average annual income that resulted from the rearing of livestock (based on respondents' perception).
2.	Efficiency	Efficiency was assessed in terms of total factor productivity and analysed on the basis of secondary data.
3.	Per capita availability	Per capita availability of milk in Haryana state by considering secondary data.
4.	Livestock productivity	Captured as the value of various items of livestock products in rupees per livestock unit.
5.	Livestock production	Accessed in terms of milk production (cattle, buffalo and goat), meat production (sheep and goat) and wool production (sheep) using secondary data.
6.	Productive livestock	Percentage of productive livestock (number of animals in milk in case of cattle and buffalo) to the total livestock population.
7.	Feed productivity	Productivity of feed input can be measured as milk produced (in litres) per Kg. of dry matter intake.
8.	Input Self Sufficiency	Assessed by directly asking from respondents regarding the quantity of concentrates, green fodder, dry fodder and supplements purchased from outside for animals.
9.	Savings and investments	Respondents were asked about how much they save from dairying and the amount they have.
10.	Marketed Surplus	The marketed surplus was assessed in term of earning (income) from sale of milk

Results and Discussion

Farm income

The average annual income from dairying was Rs. 54480.20 (Table 2.1). It was estimated per milch animal as Rs. 11291.23. Further respondents were classified into three categories on the basis of dairy income (Table 2.2). Evidently, 40% farmers were receiving annual income of more than Rs. 40000 from dairying (Table 2.2). Nearly 38 percent respondents were having average annual income of less than 20,000.

Livestock makes a significant contribution to the growth and development of India's rural economy. Farm income is considered an important signal for economic sustainability of a dairy enterprise. Farm income is the income generated directly or indirectly from livestock either by selling of livestock (directly) or by selling of livestock products (indirectly). Dairying also reduces the farmer's risk by mitigating the strain when rains are not good, keep income flowing which fulfills the aim to provide the income to the farmers throughout the year rather than on seasonal basis only (Singh and Kumari, 2017) [32]. Cattle rearing and milk production have been a source of livelihood to innumerable people in sub marginal level. The particularly rapid growth at the lower income levels was accompanied by reductions in poverty and income inequality (Gardner, 2000) [17]. Livestock contributed 16% to the income of small farm households as against an average of 14% for all rural households (Dash, 2017) [10]. Cows and buffaloes if in milk will provide regular income to the livestock farmers through sale of milk. Rural poverty is less in states where livestock contributes more to farm income (Mahapatra, 2012) [24].

(Kashish *et al*., 2017) [20] conducted a study in Punjab with a sample size of 80 and reported that the net annual income from dairying was Rs.128265, 189985, 214993 and 260446 among landless, marginal, small and other categories of dairy farmers respectively.

The data is to be taken with pinch of salt as there is a general tendency to under-report income. Further, the respondents are not in the habit of keeping records of expenses and incomes. Both of these factors may have led to the figures wherein the investment is higher and incomes are reported as lower which is likely improbable. Yet, other workers like (Suresh *et al*., 2009) [33] reported that the gross income of Rs. 22249.52 and net income of Rs.3720.28 per buffalo per annum was significantly higher as compared to Rs. 17498 and Rs.2028 per cow per annum respectively in a study conducted in Karnal district of Haryana. Marginal milch animals holding households derive a greater share of their income from dairying and daily wages (about 21 and 11 percent respectively) as compared to that by small farmers (about 18 and 0 percent respectively) as reported in one of the study conducted in Bihar. This indicates that the marginal farmers are more dependent and intensively involved in the dairying activities as compared to the small

farmers. The dairy farming systems sustainability appears low given the poor income.

Table 2.1: Estimated average annual income from dairying

Estimated annual income from dairying	Mean amount (in Rs.)
From dairying (overall)	54480.20
From dairying per animal	11,291.23
From dairying per kg milk	3.34

Table 2.2: Classification of respondents on the basis of perceived annual income from dairying

Annual income	Frequency (%)
< 20000	45 (37.5)
20000 – 40000	27 (22.5)
> 40000	48 (40)

Efficiency

Efficiency, usually expressed as the ratio of inputs to outputs, this can be calculated in biological or economic terms and often per unit of time. Animal production is a value added system which processes various inputs through livestock with the expectation that outputs will be worth more than the total input costs. A livestock farming system is economically sustainable if it guarantees a benefit that allows it to maintain itself over time, while maintaining or improving productive efficiency and decreasing economic risk (Otta *et al.*, 2016) [28]. Productivity and efficiency of livestock production is very low in developing countries, it can nevertheless be improved with considerably less inputs of fossil energy than is the case in developed countries (Preston and Murgueitio, 1992) [29].

In the present study, the available literature was used to analyze efficiency. Many workers have used total factor productivity as an indicator which measures the growth in total output which is not accounted for by growth in total inputs. The TFP index is the ratio of the index of aggregate output to the index of aggregate inputs. In India, the growth in milk production has been driven primarily by the animal numbers than their yields (Ohlan, 2013) [27]. The milk yield of dairy animals is very low in India as compared to other countries. Consequently, the country has to maintain a much larger stock to produce the required quantity of milk. In 2012-13, the average annual yield per dairy cow was estimated to be 1,284 kg of liquid milk in India, whereas it was 6,212 kg in the European Union and 9,117 kg in the United States (FAOSTAT database, 2012) [15]. Earlier, Lal and Chandel, (2017) [2] conducted a study in Sirsa district of Haryana to determine total factor productivity of milk production. The TFP has been found highest in large herds (0.2202) and for crossbred cows (0.2346). Chand and Sirohi (2015) [8] also examined long-term trends in total factor productivity of the livestock sector in Rajasthan and reported that in the span of past five decades, from 1960–61 to 2009–10, there has been a negligible growth in the TFP and its contribution to nominal and real output growth in livestock sector is about 12 per cent and 0.4 per cent, respectively. So it can be concluded that the sustainability of input driven growth remains a serious concern. Therefore, the dairy farming systems appear partially sustainable on this account.

Per capita availability

In the last three decades, world milk production has increased by more than 59 percent, from 530 million tonnes in 1988 to 843 million tonnes in 2018 (FAO, 2021) [13] and is projected to grow at 1.6% p.a. to 997 Mt by 2029, faster than most other main agricultural commodities (OECD/FAO, 2020) [26]. India is the world's largest milk producer, with 22 percent of global production (FAO, 2021) [13]. India's dairy production and consumption is on the rise with the per capita consumption of milk has increased from 4.3 litre per month in urban areas in 1988 to 5.4 litres in 2012, (Anonymous, 2020) [2]. The consumption of milk has jumped from 3.2 litres per month to 4.3 litres per month even in rural areas. The Niti Aayog has projected that the country's milk production will touch 330 million tonnes by 2033 (*ibid*).

Per capita availability of milk in Haryana state during 2018-19 was 1087 grams per day (BAHS, GOI, 2019) [5] which has increased from 800 gm/day in 2013-14 to 1087 gm/day in year 2018-19. Per capita availability of milk is continuously increasing since 1951. This may be due to the fact that milk production of the state has increased from 74.42 lakh tonnes (2013-14) to 107.26 lakh tonnes (2018-19) despite the decline in buffalo population from 57.64 lakh in 2012 to 43.76 lakh in 2019.

Although the per capita availability has increased significantly yet the reports of adulteration of milk and milk products are not uncommon. According to a report by the Animal Welfare Board, about 68.7 per cent of the milk production in the country, along with milk by products were found to be laced with polluting ingredients and these adulterants in milk are hazardous and can cause irreversible damage to human organs (Kataria, 2019) [21]. The World Health Organisation (WHO) had recently issued an advisory to the Government of India stating that if adulteration of milk and milk products is not checked immediately, 87 per cent of citizens in India would be suffering from serious diseases like cancer by the year 2025 (*ibid*).

Given the changing dietary preferences of consumers it appears that the demand for milk and milk products will continue to rise adding to the likelihood that higher production will be required to meet future demand. From availability point of view, the dairy production systems seemingly have sufficient room to expand in the future. However, how this demand will translate into opportunities for production systems will largely depend upon how the rising demand is translated into opportunities for production systems. In the past, programmes like operation flood have demonstrated that such opportunities can be used to stimulate both production and productivity. It is suggested that efforts should be made to link consumers with producers to capitalize on this constantly rising demand.

Livestock productivity

The livestock productivity was captured as the value of various items of livestock products in rupees per livestock unit and was estimated as Rs.83.067. This was estimated based upon secondary data which was obtained from latest livestock census conducted in 2019. Value of various items of livestock was considered in the terms of milk production which was then multiplied by price of milk.

Livestock production

This indicator was considered in terms of milk production (cattle, buffalo and goat), meat production (sheep and goat) and wool production (sheep) as explained earlier in chapter three. For this secondary data was taken from latest livestock census and results are drawn below in table 3. Livestock production in terms of milk in Haryana was on very higher side as compared to meat and wool.

Table 3: Table depicting summary of livestock production (2018-19) in Haryana

Sr. no.	Products of production	Species involved	Production (kg)
1.	Milk	Cattle, Buffalo and Goat	10726090
2.	Meat	Sheep & Goat	19020
3.	Wool	Sheep	718.50

Source: BAHS, GOI, 2019) [5]

Productive livestock

Productive livestock population includes the percentage of productive livestock (number of animals in milk in case of cattle and buffalo) to the total livestock population. Here both primary and secondary data was used to arrive at estimates (Table 4).

Table 4: Estimates of productive livestock based on primary and secondary data

Sr. no.	Source of data	Total Population	No. of milch animals	Productive livestock (%)
1.	Secondary	6188.55	3293.28	53.22
2.	Primary	579	245	42.31

Source: BAHS, GOI, 2019) [5]

Livestock products (meat, milk, and eggs) are among the top 10 globally traded commodities with a value of approximately US$6.5 million (FAOSTAT, 2017) [16]. Yet concerns have been expressed about production and productivity to feed the larger, more urban, richer world population. Earlier, (Alexandratos and Bruinsma 2012) [1] estimated that global food demand will increase by 1.1% per year from 2005/07 to 2050. They also expect that in this period, global demand for meat will grow by 1.3% per year and for milk and dairy products by 1.1% per year. So, compared to 2005/07, demand in 2050 is expected to be approximately 75% higher for meat and 60% for milk and dairy products.

In India also the average food basket is gradually shifting towards animal products due to the rising population of the middle income group. According to projected estimates, the domestic demand for milk and meat in 2050 is likely to be two and a half times and double the current production levels, respectively (Anonymous, 2021) [3]. In fact the situation is far more pathetic because about 17.5% (217 million) of Indian population is undernourished and the country stands at 63 rank out of 69 nations in Global Hunger Index (IFPRI, 2013) [19].

In the present study, both livestock productivity and production were analyzed using secondary data. The livestock productivity per animal (cattle & buffalo) in Haryana was estimated in monetary terms as Rs 83.067 which is on lower side. The productive livestock population was 42.31% and 53.22 % based on primary and secondary data respectively. The overall production of milk in Haryana state is 107.26 lakh tonnes in 2018-19 (BAHS, GOI, 2019) [5]. Yet, in the given circumstances, the demand for milk and milk products is likely to expand suggesting there is enough room for growth. However, such a growth has to come by bringing about improvements in productivity of animals if the sustainability of production systems is to be augmented. The argument has earlier been put forth also. For example the National Livestock Policy (2013) [25] stresses upon need to improve productivity of livestock through proper breeding, feeding and disease control programs.

Feed productivity

In coming 50 years it is necessary to increase the productivity of major livestock species to address the food needs of the world, while at the same time minimizing the environmental impact. In this study input productivity was considered in the terms of feed and was estimated 0.64 Lit/Kg. dry matter intake indicating poor feed conversion efficiency of livestock in general. Chand (2008) [7]also estimated the average feed productivity of 0.5 in Rajasthan and for small, medium and large categories of households it was 0.43, 0.45 and 0.48 respectively. So in the context of feed productivity livestock farming appears partially sustainable in Haryana.

Input self sufficiency

This indicator was assessed by directly asking from respondents. As is clear from the Table 5, all respondents purchased concentrates from outside. About 50 % dairy famers purchased both green and dry fodder from outside (Fig 1). Further all respondents purchased 100% supplements from outside (Table 5). It can be concluded that input self sufficiency in general was poor.

Moreover, dairy farming systems are facing major changes and uncertainty related to price volatility, socio-cultural values and political aspects (Lebacq *et al.,* 2015). [23] Increasing input self-sufficiency constitutes a possible pathway to design systems that are more sustainable and able to operate in this changing context *(ibid*). Bernues *et al.,* (2011) [6] defined self-sufficiency as 'the capacity of the system to regulate and control its interaction with the environment'. Self-sufficiency can also be an advantage for highly uncertain and volatile markets. Lower dependence on external inputs reduces the effects from scarce resources or price fluctuations (ibid). In the literature, input self-sufficiency has often been used as an attribute of sustainability in livestock farming system analyses (e.g. Ripoll-Bosch *et al.,* 2012). [31] It has also been considered as a key principle of agroecology for animal systems (Dumont *et al.,* 2013), [11] as well as a strategy to improve their resilience (Darnhofer, 2010) [9].

Traditionally, mixed farming systems have been considered to be operating in closed loops. These systems were having less dependence on external inputs because of cycling of input outputs with in the system and were more sustainable. It can be concluded that input self sufficiency in general is on decline given the degree of reliance on the outside inputs. Naturally, it leads to increased vulnerability to outside factors making production systems less immune to outside shocks and pressures. This in turn can create pressures making production systems less sustainable.

Table 5: Table depicting respondent's input self sufficiency status

Sr.no.	Statements	Yes Frequency (%)	No Frequency (%)	If yes (how much %)
1.	Do you purchase concentrates for your animals from outside ?	120 (100)	0	65.28
2.	Do you purchase green fodder for your animals from outside ?	62 (51.7)	58 (48.3)	42.08
3.	Do you purchase dry fodder for your animals from outside ?	60 (50)	60 (50)	42.04
4.	Do you purchase supplements for your animals from outside?	120 (100)	0	100

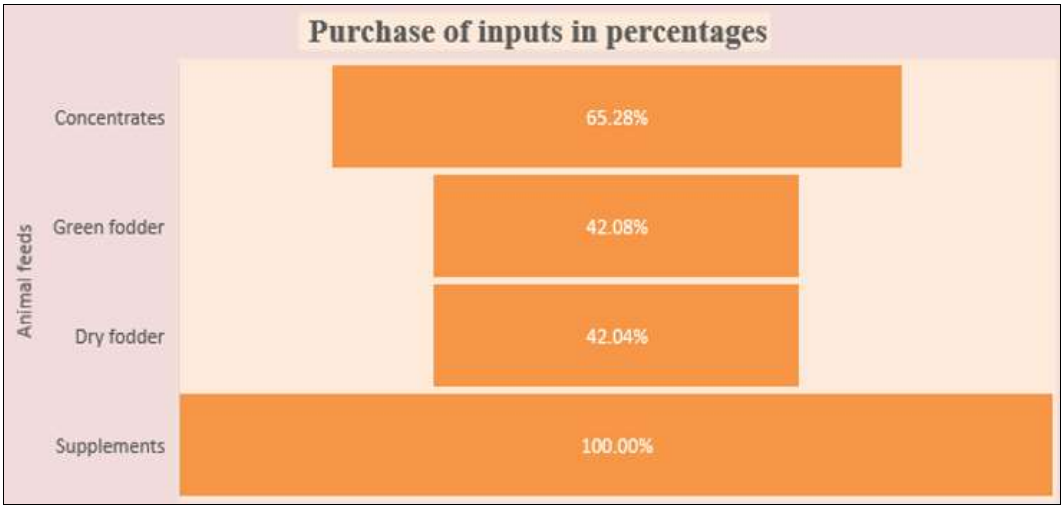

Fig 1: Figure depicting Input self sufficiency status of respondents

Savings and investments, Marketed surplus

Animal husbandry is one of the most lucrative and demanding business not only in India but across the globe. In the rural areas of many developing countries financial services such as credit, banking and insurance are virtually non-existent. In these areas, livestock play an important role as a means of saving and capital investment, and they often provide a substantially higher return than alternative investments. A combination of small and large livestock that can be sold to meet petty-cash requirements to cover seasonal consumption deficits or to finance larger expenditures represents a valuable asset for the farmer.

Table 6: Table depicting summary of savings and investments in animal keeping

Sr. no.	Statements	Average amount (in Rs.)
1.	Annual savings from dairying	56255.20
2.	Annual investments in dairying	96116.66
3.	Annual savings per Kg milk produced	3.45
4.	Annual savings per animal	11659.10
5.	Annual investment per animal	19920.55
6.	Annual investment per Kg milk produced	5.89

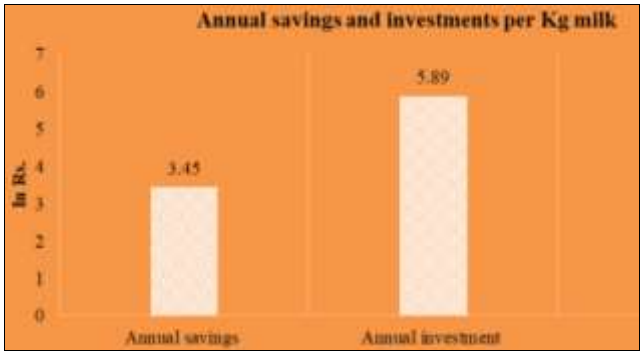

Fig 2: Annual Savings and Investments per Kg milk

In the present study, the respondents by and large perceived that the investments are higher in this enterprise than the savings (Table 6). There have been concerns expressed by other workers also. For example (Arora 2019) [4] opined that farmers are not getting remunerative prices for their milk against the cost of production in Haryana. Consumer prices for fresh milk in the informal sector were slightly higher than in the formal sector. The prices paid to the farmer for 6 percent fat milk was very close to the consumer price for 3 percent fat milk (Hemme *et al.*, 2003) [18]. Farmers are bearing the brunt of malpractices in the animal trade due to the presence of intermediaries who lure the farming community on the pretext of providing good germplasm of high-yielding animals (*ibid*).

Marketed surplus is the gross quantity of produce actually sold by the farmers which directly affect the profit. Here marketed surplus was assessed in term of earning (income) from sale of animal and animal products (milk, ghee). The earnings from sale of milk were higher in comparison to earnings from sale of ghee and animals. Most of the farmers preferred to sell milk in comparison to ghee as nearly 70 % of milk was sold daily and 53% of ghee out of total was sold daily by respondents (Table7). It appear that respondents were not getting fair prices by selling milk to dairy co-operatives because most of them were selling milk directly to consumers (table 7). Only a small percentage of respondents were selling milk to co-operative societies. So in the context of savings and investments, sustainability of livestock farming appear on lower side. Yet the qualities / promotion of marketed surplus seemingly indicates that farmers are relying significantly on the proceeds from milk and products.

Table 7: Table depicting summary of milk and milk products marketed by respondents

Sr. No.	Statements	Result	
1.	How much did you earn from sale of milk from your animals in past 2 years?	Rs. 73454.16	
2.	How much did you earn from sale of ghee from your animals in past 2 years?	Rs. 49625	
3.	How much did you earn from sale of animals in past 2 years?	Rs. 22945.83	
4.	What % of milk do you sell daily?	68.07%	
5.	What % of ghee do you sell?	52.77%	
6.	Average price of selling milk	Rs. 53.73	
7.	Average price of selling ghee	Rs. 770.65	
8.	Percent of farmers selling milk	51.66%	
9.	Percent of farmers selling ghee	20%	
			Frequency (%)
10.	To whom do you sell milk?	Direct consumers	33 (60)
		Milkman	15 (27.27)
		Co-operative dairy society	7 (12.72)

Conclusion

Overall dairy production systems appear low sustainable on economic pillar. Indicators which strongly favours sustainability includes per capita availability and marketed surplus, Similarly the dairy farming systems were found low sustainable in terms of farm income, livestock productivity, production & Productive livestock, input self sufficiency, savings and investments and marketed surplus. It is suggested that ways and means to improve efficiency of production will have to found if the production system are to become sustainable. It is suggested that dedicated extension campaigns to promote balanced feeding should be initiated with a focus to improve feed productivity. Strategies to enhance livestock productivity, decrease production costs, facilitate better access to credit, boost self-sufficiency in production systems, and improve feed efficiency are recommended.

References

1. Alexandratos N, Bruinsma J. World agriculture towards 2030/2050: the 2012 revision. Rome: Food and Agriculture Organization of the United Nations (FAO); 2012.
2. Anonymous. Budget 2020: India to double milk processing by 2025; every citizen to have this much more daily. Available at: https://www.financialexpress.com. Accessed 2021 Feb 6.
3. Anonymous. Meat, milk and more. Available at: https://www.tribuneindia.com. Accessed 2021 Jan 14.
4. Arora P. Maintaining milk quality a challenge. Available at: https://www.tribuneindia.com. Accessed 2021 Feb 1.
5. Basic Animal Husbandry Statistics (BAHS). Ministry of Agriculture. Department of Animal Husbandry, Dairying and Fisheries; 2019.
6. Bernues A, Ruiz R, Olaizola A, Villalba D, Casasus I. Sustainability of pasture-based livestock farming systems in the European Mediterranean context: synergies and trade-offs. Livest Sci. 2011;139:44-57.
7. Chand P. Sustainability assessment of production systems in Rajasthan [dissertation]. Karnal (India): National Dairy Research Institution; 2008.
8. Chand P, Sirohi S. Sectoral priorities for sustainable livestock development in Rajasthan: Lessons from total factor productivity growth. Agric Econ Res Rev. 2015;28(conference number):81-92.
9. Darnhofer I, Bellon S, Dedieu B, Milestad R. Adaptiveness to enhance the sustainability of farming systems: A review. Agron Sustain Dev. 2010;30:545-55.
10. Dash S. Contribution of livestock sector to Indian economy. Paripex - Indian J Res. 2017;6(1):890-1.
11. Dumont B, Fortun-Lamothe L, Jouven M, Thomas M, Tichit M. Prospects from agroecology and industrial ecology for animal production in the 21st century. Animal. 2013;7:1028-40.
12. Food and Agriculture Organization (FAO). How to feed the world in 2050. Rome: FAO; 2009.
13. Food and Agriculture Organization (FAO). Gateway to dairy production and products. Available at: http://www.fao.org/dairy-production-products/production/en. Accessed 2021 Feb 3.
14. Food and Agriculture Organization (FAO). Unlocking the potential of sustainable livestock production. Global Conference on Sustainable Livestock Transformation; 2023.
15. FAOSTAT database. Production-Livestock Primary. Available at: http://www.faostat.fao.org. Accessed 2020 Dec 3.
16. FAOSTAT Statistics database of the Food and Agriculture Organization of the United Nations (FAO). Rome (Italy): FAO; 2017. Available at: http://faostat3.fao.org/.
17. Gardner BL. Economic growth and low income in agriculture. Am J Agric Econ. 2000;82(5):1059-74.
18. Hemme T, Garcia O, Saha A. A review of milk production in Haryana – India with special emphasis on small milk producers. PPLPI working paper No. 2. Rome: FAO; 2003.
19. International Food Policy Research Institute (IFPRI). Global hunger index: The challenge of hunger: Building resilience to achieve food and nutrition security. Washington, DC: IFPRI; 2013.
20. Kashish A, Kaur M, Sekhon MK, Dhawan V. Impact of dairying on income and income distribution of smallholder dairy farmers in Punjab. Indian J Dairy Sci. 2017;70(6):781-8.
21. Kataria A. Milk contamination in India - The ways and reasons. Available at: http://www.fnbnews.com. Accessed 2021 Feb 9.
22. Lal P, Chandel BS. Total factor productivity in milk

production in Haryana. Agric Econ Res Rev. 2017;30(2):279-84.
23. Lebacq T, Baret PV, Stilmant D. Role of input self-sufficiency in the economic and environmental sustainability of specialized dairy farms. Animal. 2015;9(3):544-52.
24. Mahapatra R. Rise of livestock. Available at: https://www.downtoearth.org.in. Accessed 2021 Jan 21.
25. National Livestock Policy. Department of Animal Husbandry, Dairying & Fisheries. Ministry of Agriculture, Government of India; 2013.
26. OECD/FAO. OECD-FAO agricultural outlook 2020-2029. Rome: FAO; 2020. Available at: https://doi.org/10.1787/1112c23b-en.
27. Ohlan R. Efficiency and total factor productivity growth in Indian dairy sector. J Int Agric. 2013;52(1):51-77.
28. Otta S, Quiroz J, Juaneda E, Salva J, Viani M, Filippini MF. Evaluación de sustentabilidad de un modelo extensive de cría bovina en Mendoza, Argentina. Rev Fac Cienc Agrar Univ Nac Cuyo. 2016;48:179-95.
29. Preston TR, Murgueitio E. Strategy for sustainable livestock production in the tropics. Cali (Colombia): CIPAV-SAREC; 1992. p. 89.
30. Rigby D, Woodhouse P, Young T, Burton M. Constructing a farm level indicator of sustainable agricultural practice. Ecol Econ. 2001;39:463-78.
31. Ripoll-Bosch R, Diez-Unquera B, Ruiz R, Villalba D, Molina E, Joy M, *et al*. An integrated sustainability assessment of Mediterranean sheep farms with different degrees of intensification. Agric Syst. 2012;105:46-56.
32. Singh P, Kumari B. Importance of livestock sector in doubling farmers income by 2022. Indian J Econ Dev. 2017;13(2a):136.
33. Suresh R, Tripathi RS, Solanki A. Comparative economics of buffalo and cow milk production in Karnal district of Haryana. Indian J Anim Res. 2009;43(3):224-5.
34. Ten Napel J, van der Veen A, Oosting S, Koerkamp P. A conceptual approach to design livestock production systems for robustness to enhance sustainability. Livest Sci. 2011;139:150-60.
35. Van Calker KJ. Sustainability of Dutch dairy farming systems: A modelling approach [dissertation]. Wageningen (Netherlands): Wageningen Universiteit; 2005.
36. World Bank. Moving towards sustainability: The livestock sector and the World Bank. Available at: https://www.worldbank.org.
37. World Commission on Environment and Development. Our common future. Oxford (UK): Oxford University Press; c1987. p. 383.