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Study on cost of milk production and measure to reduce the milk production cost

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Team Leader
Study Team
June 2022

Chairman
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EXECUTIVE SUMMARY

Primary data was collected using two approached-a farmers' survey and a key informant interview (with the local people involved in the dairy business, public organizations, local level organizations or the milk collection cooperatives). A total of 599 respondents were interviewed in all 24 study districts of all seven provinces. It included personal interviews with 530 milk producer farmers, 29 key informants and 40 individuals working in various capacities in the dairy cooperatives of the selected districts.The survey and subsequent data collection were done electronically using hand-held electronic devices.The data was analyzed in descriptive statistics using MS Excel and further economic analysis was made in the SPSS platform on a Windows machine.

Among the surveyed participants, half of the respondents were cattle farmers whereas, among the remaining half, there was an equal number of buffalo and mixed farmers. In cattle-only farms, the average number of milking animals was four. In terms of breed, the average number of Jersey was three, and the average number of HF, local cows, and local cows was two. In farms with buffaloes only, the average number of milking animals was five per household. Among the buffaloes, the average Murrah breed was four, that of local was one and the crossbreds was three per household.

The average total cost of livestock producers was NPRs 8851.62 per adult animal per month. The cost of livestock rearing was lowest in Lumbini province (NPRs 5853) and highest in Karnali province (NPRs 9140.67). According to the data obtained, the most important cost item was feed/nutritional costs accounting for 64% of the total costs, followed by labour cost (9.32%), animal costs (6.58%), vitamin& calcium (3%) and shed cost (2.97%) of the total costs.

On the scale of operation, the variable costs per adult milk animal per month wereNPRs6972.47, 7543.11 and 8961.65 respectively for large, medium and small scales of operation.The all-scale average variable cost of livestock producers was NPRs 7825.74 per adult milk animal. Similarly, the fixed cost per adult milk animal per month was NPRs 1286.96, 1085.6 and 705 respectively for large, medium and small scales of operation. The all-scale fixed cost of livestock producers was NPRs 1025.87 per adult milk animal. In the same manner, the total cost per adult milk animal wasNPRs 8259.4, 8628.71 and 9666.7 respectively for large, medium and small scale operations.The all-scale average total cost of livestock producers was NPRs 8851.62 per adult animal.

For cattle only, buffalo only and mixed farms, the variable costs per adult milk animal were NPRs 7218.32, 8057.35and 8201.66 respectively, whereas the fixed costs per adult milk animal were, NPRs 893.17, 1152, and 1032.95 respectively.The total costs per adult milk animal were NPRs 8111.3, 9209.42, and 9234.62 respectively for these kinds of farms.

The average milk yield per lactation period per milk animal was 1600, 1525, and 1400 litres for the large, medium and small scale of operation respectively. Based on this milk yield, the gross income of large, medium and small farmers was NPRs. 15375.24, 14247.36, and 12938.54,respectively and on average the gross income was NPRs 14173.9. The net income from livestock production was NPRs 5322.3 onan all-scale average basis.

The cost of production per litre milk per milk animal was NPRs51.62, 56.6, and 67.83 for the large, medium and small scale farms respectively. The average cost per litre milk per milk animal was NPRs 58.7. The average price received by the farmer per litre of milk was NPRs 92.36, 89.65, and 88.38 for the large, medium and small-scale dairy farms respectively while the overall all-scale average price received per litre of milk was NPRs 90.13.

The average margin per litre of milk was NPRs 40.74, 33, and 20.55 for the large, medium and small-scale dairy farms respectively and the all-scale average margin per litre of milk was NPRs 31.43. The results also showed that the highest price per litre of raw milk was prevalent in the cooperative-buyer channel (NRs 83.01) followed by the producer-buyer channel (NRs 82.8), producer-cooperative channel (NRs 81.1) and cooperative-dairy channel (NRs 78.9).

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1. INTRODUCTION

Agriculture is the backbone of the Nepalese national economy. The contribution of the agriculture sector to national GDP is 27.1%[1], while the contribution of the livestock sector to agricultural GDP (AGDP) is around 28%. Livestock is an integral and important component of the mixed farming system in Nepal. The sector not only contributes to the national GDP but also ensures the flow of money from urban to rural Nepal. The dairy sector not only provides household nutrition but also ensures the flow of money (Rs 60 million daily) from urban to rural Nepal[2].

Organized dairy development activities in Nepal began in 1952 with the establishment of a Yak cheese factory in Langtang of Rasuwa district under Food and Agriculture Organization (FAO) assistance in 1953. In 1954, a Dairy Development Section was established under the Department of Agriculture (DoA) and also a small-scale milk processing plant was started in Tusal, a village intheKavre district. In 1955, a Dairy Development Commission was formed. The First Five Year Plan (1956-61) stressed the need to develop a modern dairy industry. Accordingly, in 1956, a Central Dairy Plant, with an average milk processing capacity of 500 litres/hour was established in Lainchaur, with financial assistance from New Zealand and technical assistance from FAO. Around the same time, a second mini milk processing plant was established at Kharipati, in the Bhaktapur district. The plant started processing milk and marketing activities in 1958. In the process, before 1960, two additional cheese factories were established under the DoA in the other two alpine districts of the country. In 1960, a Cheese Production and Supply Scheme was also established. The Dairy Development Commission was converted to the Dairy Development Board in 1962. To meet the growing demand for milk in Kathmandu, the Board was converted to Dairy Development Corporation (DDC) in 1969[3].

NDDB was established in 1992 to strengthen the dairy sector in Nepal through policy formulation and recommendation. Some of its functions include acting as a coordinating body between the private and public sectors, formulating and recommending pricing policies for milk to the Government of Nepal (GoN), monitoring and evaluating dairy development programs and mobilizing funds for dairy sector development.

[1]https://www.mof.gov.np/uploads/document/file/Economic%20Survey%202019_20201125024153.pdf
[2]https://nddb.gov.np/storage/uploads/lNTJBRxnkTXAy3T8BWu8gjARAzfVgnl15VpH6rFT.pdf
[3]https://un.info.np/Net/NeoDocs/View/History/Default.aspx?RefId=3388

Dairy is the most important sub-sector in the livestock sector contributing 9% of the GDP and 63% of livestock gross domestic product (LGDP) and 9% of AGDP[4]. There are more than 500,000 dairy farmers and 1700 dairy cooperatives involved in the dairy sector in the country, generating employment and income in rural Nepal. The investment in the dairy sector is about Rs 30,000 million and the sub-sector provides direct employment to 20 thousand persons[5].This sector holds billions of investments and also generates the same level of employment. The sustainability and the competitiveness of the entire sector solely depend on the efficiency of milk production, demand and supply and price policy.

Half of the total milk produced is self-consumed and/or retained by the producer farmers and the rest is traded at formal and informal sectors in the dairy industry, milk collection centres, milk cooperatives, sweetshops, local markets, neighbours, hotels and restaurants. Recent data projected by the NDDB[6] itself shows that in the year 2076/77 a total of 332729723 litres of milk was collected through the formal channel of trade in Nepal. Among these, the maximum collection (171074233 litres) was made in the Bagmati province whereas the minimum collection (2524000 litres) was made in the Karnali province. The available data also shows that there is a gradual increment in milk production in Nepal however, the COVID-19 pandemic and its consequence thereafter has hit this sector hard. Similarly, among the farmers who produce 8-10 litres of milk per day, household consumption equates to somewhere around 30%. It is also interesting to note that with an increase in the number of animal heads and milk productivity, the average household consumption percentage decreases. But this is highly variable and influenced by multiple factors such as the number of household persons, availability of markets, number of dairy animals, geographical location, milk cooperatives in the vicinity and availability of road/ transportation facilities, just to name a few.

Dairying is recognized as a prestigious occupation among the other agricultural sub-sectors and is contributing to pulling the urban capital to the rural area. It has been one of the best cash-generating occupations. It attracts youth and is gradually developing as an enterprise. To provide income and employment on a larger scale, smallholder farmers should be encouraged and facilitated with improved livestock rearing, soft loan facilities and appropriate training on good husbandry practices and clean milk production. Moreover, this sector has not been able

[4]https://moald.gov.np/wp-content/uploads/2022/04/Statisticalinformationon Nepaleseagriculture2076/77 (2019/20).pdf
[5]https://nddb.gov.np/storage/uploads/GLtIwiH2Xv7l3YSTsmJSrjUqUYnT9VUkvrwb06LL.pdf
[6]https://nddb.gov.np/storage/uploads/06ekuZ3GsKTQ3yaM6OvRHUskbWYpqYY52UODfwaf.pdf

to accelerate the pace, as the cost of production is much higher compared to neighbouring countries.

Milk production in Nepal is still carried out under the traditional production system, in the mixed farming system, with small non-commercial holdings. A persistent problem the dairy industry faces is poor milk quality. This is associated with a lack of farmer awareness concerning hygienic milk production which causes a loss of income along the milk chain. Due to the lack of a comprehensive policy that provides standards to be complied with during milk production, the quality of milk in Nepal has remained a big issue. The basic reasons are attributable primarily to the lack of hygiene and inadequate sanitation at the production level, since major milk producers are small, marginal and poor, living at the subsistence level.

The trend of milk production in the country is increasing by 4.3% annually[7]. The causes of the increment are improved breeding, feeding, animal health, shifting to commercial dairy farming and the dairy value chain development. On the other hand, the cost of inputs (feed, animal health, medicine, breeding, labour, dairy utensils etc.) for milk production is increasing day by day but milk price is constant last over a couple of years (five years' dairy development plan[8].

Around 50% of milk is utilized locally for home consumption as well for indigenous dairy products; 33% passes and is marketed through the informal channel and reaches the consumers and end-users, and the remaining 17% only of total production passes through the public and private sector dairy processing plants which comes around to 1.1 million litres of milk per day on a yearly average[9].

As per WHO, the per capita consumption requirement of milk is 92 litres, however, availability is 79 litres only. It is estimated that the average current deficit is around 550,000 litres of fluid milk per day with 10-20% variability during the lean season (Mar-Jul) and flush season (Aug-Feb). Production is increasing in the range of 4.3% annually, but demand is growing at 8%. As supply is not keeping up the pace with demand, the demand-supply situation is likely to widen over the years if the current milk production growth rate is not increased.

[7]https://moald.gov.np/wp-content/uploads/2022/04/Statistical information on Nepaleseagriculture2076/77 (2019/20).pdf
[8]https://nddb.gov.np/storage/uploads/ZObrGIBCY5C6pBGLD9rtoBcrcfdlr72C9l2C0DU1.pdf
[9]https://nddb.gov.np/storage/uploads/abrdRmdP7Y6r0yOM8g0nuNYBm5kM9IqE7qvYs9fQ.pdf

In Nepal, buffalo milk is synonymous with milk. This is the most preferred milk for Nepalese consumers. Moreover, buffalo milk is preferred by processors for making fat-based products, including ghee, butter, Mozzarella cheese, etc. due to its high fat and high total solid content. The share of buffalo milk is 60% (approximately 7.21% in AGDP) and cow milk is 40% (approximately 3.84% in AGDP) in total milk production in Nepal[10]. The high yield of buffalo milk suggests a high proportion of improved buffaloes, especially in accessible areas. The preference for buffaloes for milk production has led to a great demand for the high-yielding Murrah breed. This preference for buffaloes has led to a burgeoning business for buffalo traders. The buffaloes are brought from Indian border areas in the lowlands and sold for a modest profit through various centres in the country. Different reports claimed that globally a total of 1000000 families are engaged in the dairy sector[11].

Despite its importance & contribution to the national economy, the Nepalese dairy sector remains delicate and unstable with frequent market ups and downs. In 1992, the practice of 'Milk Holiday' started in the flush season. Private dairy industries with various capacities were established to address this situation. Gradually the demand for fluid milk increased and many dairy farms were established. Again, the supply side exceeded the demand of processing industries and thus powder milk plant was established to absorb excess milk during the flush season. However, due to many internal and external factors, including quality & price fluctuation of SMP in international markets, the newly established milk processing plant with the capacity of processing 320,000 litres of milk per day producing SMP and butter couldn't compete and survive.

National Dairy Development Board (NDDB) is the apex level policy-making body formed by the government of Nepal in 1992 for holistic dairy sector development in the country. Some of its functions include; acting as a coordinating body between private and public sectors, formulating and recommending price-fixing policies for milk to the Government of Nepal (GoN), monitoring and evaluating dairy development programs and mobilizing funds for dairy sector development.

Gradual commercialization of dairy animal farming has been coming up to fill the gap of fluid milk deficit and reduce the milk production cost. The milk production cost relates to many factors and therefore the milk price should be determined by considering each factor

[10]https://moald.gov.np/wp-content/uploads/2022/04/Selected indicatorsofNepalese agriculturepocketbook2021.pdf
[11]https://www.ciwf.org.uk/media/5235182/Statistics dairycows.pdf

contributing to the milk production cost. The current pricing system is appreciable but the pricing policy has to be updated and improvedto encourage the development of this sector. The present study is therefore being commissioned to assess the production cost and suggest the NDDB for necessary action. NDDB has been conducting a study on the cost of milk production on regular basis. Based on the study and discussion with concerned stakeholders, the minimum price of milk is recommended to MoALD for necessary action. Usually, the trend of price-fixing is done in a manner where 69% of the price goes to the farmers and 31% to the processors. After evaluation of these processes, the MoALD approves the consumer price of milk after which Dairy Development Corporation (DDC) implements it and private dairies follow as well.

1.1 Objective

The overall objective of the study is to assess the milk production cost and recommend an appropriate price for raw milk to be purchased by the processors. Following are the specific objectives:

1. To identify different types and capacities of dairy farms.
2. To study the annual milk production of cows and buffalo.
3. To study and assess inputs in milk production (feeding, breeding, animal healthetc).
4. To assess the fixed cost and variable costs of a dairy farm at different production levels and different production systems.
5. To estimate per unit milk production cost of different types of farms and recommend appropriate selling price.

1.2Scope of the Study

1. Review the milk price received by farmers from formal and informal sectors based on physio-chemical quality.
2. Review the milk production cost and rate of standard pasteurized milk in the last fifteen years.
3. Review literature; the national and international practice of milk pricing system (neighbouring states of India).
4. Estimate average milk production by a cow (local and crossbreed) and buffalo (local and crossbreed) in one lactation.
5. Analyze the knowledge, attitude and practice (KAP) of farmers to the trend of milk production.

6. Analyze the factors influencing the milk production cost including the weighted effect of each factor (feeding, animal health, breeding, manpower, AI, management, insurance, etc.).
7. Identify and analyze the province-based milk production cost on a different levels of dairy farm size (small, medium and large) and different production systems (traditional, semi-commercial and commercial).
8. Identify the contribution of subsidies in reducing milk production costs.
9. Identify fixed and variable costs of dairy farms at different levels and different production systems.
10. Recommend internationally accepted scientific milk pricing system relating its practicability in our context.
11. Recommend quality-based milk price per litre and measures to reduce the milk production cost.

1.3Rationale of the study

Commercial dairy farming in Nepal is a very recent phenomenon and has not seen many success stories. This is mainly because the high cost of production of milk that reduces the expected benefits for the farmers. Farmers often complain that most of the price they get from the sale of milk is ploughed back into purchasing feed for their livestock. Therefore, lower milk prices and increasing feed costs could jeopardize the economic viability of raising livestock. NDDB evaluates the farmer's cost of production of milk and forwards the same to the MoALD. Based on this evaluation, Dairy Development Corporation (DDC) recommends the milk price based on the fat and SNF content to its board for its approval. Once approved this price is taken as the benchmark. The price received by the farmers is widely reported to be just adequate to cover their production costs.

The cost of production of milk relates to many factors and therefore the milk price cannot be determined in isolation. The price the farmers receive for their milk is their most immediate concern, yet little seems to be known about the calculations and factors that go into determining farm-gate prices. The current pricing systems have some limitations and flaws thus; scientific pricing policy has to be rolled out to improve and encourage the development of this sector. Besides, the price is not a static concept. This is dynamic and the total output depends onseveral variables some of which may not be within the control of the farmers. So the pricing policy must be updated and revised at certain time intervals.

2. REVIEWOFLITERATURE

A review of the literature was done for collecting the secondary data and information. Previous study reports on the cost of milk production, size and capacity of the dairy farm, annual milk production of cow and buffalo, list of dairy industries, list of dairy cooperatives, dairy and livestock-related services and activities run by various organizations were collected for review. This literature included published study reports, articles, and research papers acquired in the form of hard copies and soft copies through internet surfing and visiting the relevant agencies.

2.1 Global dairy industry

The dairy sector worldwide has experienced a remarkable growth story over the last two decades. International trade defines the national milk prices – and farmers have toadapt to these conditions. Farmers manage to generate a farm income despite high cash costsanddecoupled subsidies are well-received to pay for opportunity costs. The farm structure in Denmark has consolidated considerably and will continueto do so to keep dairy farms internationally competitive. Above half of the world's total milk production has originated in developing countries such as India but still, the milk yield per cow is less than in other countries. In India, dairying has been considered one of the activities aimed at alleviating poverty and unemployment, particularly in the rural areas in rain-fed and drought-prone regions. Moreover, this sector is crucial for reducing income inequalities.

A study from India[12] had shown that the average milk yield was 10.50 litres, 11.53 and 15.80 litres for buffalo, Jersey cow and Holstein Friesian cow, respectively. In terms of milk production as well as production traits, the Holstein Friesian and Jersey cows were superior to buffaloes and local cows. A 2019 report[13] of IFCN has mentioned that the average number of milking animals per farm varies globally. In the North Americas, this is 204 cows, in Latin America, this is 28 cows, in Europe, this is 20 cows, in Africa, this is 5 cows, in Oceania this is 367 cows and in South Asia, this is only 2 cows. Most of the farms in Africa and Asia and a few farms in Latin America generally have a herd size of fewer than 10 animals per farm. In Asia the average farm size found was 1.9 cows per farm which shows the dominance of smallholder household farms with dairying as a subsidiary occupation. These are the

[12] R. Kumwat, NK Singh and CL Meena. 2014. Economic analysis of cost and returns of milk production, extent of adoption of recommended management practices on sample dairy farms in Bikaner district of Rajasthan. Global Journal of Science Frontier research, Vol. XIV, Issue V, Version I

[13]https://www.landbrugsinfo.dk/-/media/landbrugsinfo/public/e/6/0/kk20_56_dorothee_boelling.pdf

subsistence farms or small-scale farms. On the other hand, countries with an average farm size of more than 100 cows per farm were the United States of America, United Kingdom, Denmark, New Zealand, Argentina, Australia, Saudi Arabia, South Africa and Israel. The highest average herd size was registered in Oceania where New Zealand has more than 400 cows per farm followed by South Africa with more than 360 cows per farm and Australia with more than 280 cows per farm. These countries have a pastoral scheme which is run atalow production cost and enables milk to be produced according to world market conditions. Furthermore, a continuous increase in herd size in the previous years has enabled them to realize economies of scale.

Denmark is the country with the highest average cow number in Western Europe (>200 cows/farm). Nearly 75% of all cows are on farms with 100 – 300 cows (large family farms), and farms with >300 cows have appeared over the last 10 years[14].

2.2 Dairy industry andenvironment

The researchers identified that land use differed more in the largest farms, which used nearly 2.25 times lesser land per kg of milk compared to the smallest farms[15]. For the mid-sized farms, the potential of global warming, terrestrial acidification, marine eutrophication, and eco-toxicity was comparatively high. The aforementioned researchers opined that if the presently used domestic farm-based protein feeds are replaced with imported high-protein soy-based feed, then the environmental impacts of dairy production can significantly increase (e.g., increased land use by 18% with global warming potential by 43%). Further, theyalso mention that the environment-based policy for handling the farms needs to sensibly contemplate the complete consequences of operation size on the environmental quality, and thus facilitate the ‘best practice’ for each farm type and driving for the systematic changes there-off. In another report[16], the adoption of various free-stall management techniques was studied as a means to lessen ammonia, greenhouse gas, and some air pollutants from lactating dairy cattle wastes. It was concluded that the removal of dairy manure by ‘scraping’ holds a high prospective to enhance gaseous emissions such as ammonia and other greenhouse gases.

The demand for environmental sustainability practices has increased in a variety of economic sectors worldwide. In animal production, in which the environment (soil, water, atmosphere,

[14]https://www.landbrugsinfo.dk/-/media/landbrugsinfo/public/e/6/0/kk20_56_dorothee_boelling.pdf
[15]https://linkinghub.elsevier.com/retrieve/pii/S0022030209703261
[16] Ross, E.G.; Peterson, C.B.; Zhao, Y.; Pan, Y.; Mitloehner, F.M. Manure flushing vs. scraping in dairy free stall lanes reduces gaseous emissions. Sustainability.2021, 13, 5363.

and temperature, among others) is one of the main factors of production, such demands are even more necessary and urgent. Small changes in the production environment can result in important negative impacts on animal production as well as on the environment and society as a whole. Although environmental sustainability practices have been adopted in many dairy production systems, such practices should be increased in the coming years. Acceleration of the adoption of environmental sustainability practices is generally promoted by two major axes- first, through laws that regulate and oversee such practices and, second, through the generation of market incentives. Between these two axes, the generation of laws and oversight mechanisms may present more weaknesses, especially considering delays in the definition of laws and the difficulty, and high costs of monitoring compliance with governmental requirements. Thus, there is a tendency for the acceleration of the adoption of sustainability practices in dairy systems to be driven by market mechanisms, particularly those that result in milk valorization. For instance, farmers who adopt a set of more environmentally sustainable production practices could be paid more per litre of milk[17]. Valorization of milk produced in systems with reduced environmental impact generally results from stable commercial relations, mainly via the establishment of purchase and sale contracts with clear clauses that can be verified by the different parties involved. Such a scenario is not observed in some countries that rank among the world's largest milk producers. Furthermore, the identification of constraints or incentives to adopt environmental sustainability practices from the perspective of farmers may contribute to the creation of important public-private strategies for accelerating the use of environmental sustainability practices in dairy production.

2.3 Global milk production

Global milk production[18] reached nearly 906 million tonnes in 2020, up 2.0 percent from 2019, driven by output increases in all geographical regions, except in Africa, where production remained stable. Milk volume increases were highest in Asia, followed by Europe, the Americas, Oceania and Central America and the Caribbean.

In Asia, milk output rose to 379 million tonnes in 2020, up 2.6 percent year-on-year, principally driven by increases mainly in India, China, Pakistan and Turkey. Kazakhstan,

[17] Rajeev B, JD Pasquale, FI Bankuti, TTS Siqueira, P Shine, MD Murphy. Global dairy Sector: Trends, Prospects and Challenges. MDPI Sustainability.2022, 14, 4193. DOI: 10.3390/su14074193

[18] https://www.fao.org/3/cb4230en/cb4230en.pdf

Uzbekistan and Japan too registered moderate production expansions[19]. In India, milk output reached 195 million tonnes in 2020, up 2.0 percent from 2019, underpinned by the continued rise in dairy cattle numbers and improved feed and fodder availability on favourable monsoon rains (June to September). The fast mobilization of the village cooperatives' network in the early phase of the pandemic and the channellingof milk into drying plants further facilitated milk output growth[20]. In China, the increased output of large-scale dairy farms and their operational and production efficiency improvements underpinned the over 7 percent milk output growth[21]. In Pakistan, milk output increased by 3.2 percent, mainly due to a rise in cattle numbers, partially offset by poor milk collections during the pandemic's early phase[22]. Besides herd numbers, farm efficiency improvements and solid import demand helped Turkey to sustain milk production growth. In Kazakhstan and Uzbekistan, two of the largest milk producers in Central Asia, the output increase reflected modernizing farms with rising dairy cattle, although smallholders remain the dominant force[23].

In Europe[24], milk output rose to 236 million tonnes, up 1.6 percent from 2019, mainly due to production increases in the European Union, the Russian Federation and Belarus. In the European Union, yield improvements, a slight increase in dairy cattle numbers and robust internal and foreign demand were behind the production expansion. In North America, milk output reached nearly 111 million tonnes in 2020, up 2.1 percent from 2019. In the United States of America, milk output rose by 2.2 percent to 101 million tonnes, driven by increased dairy herd numbers and milk yields. In Central America and the Caribbean, milk production expanded by 1.6 percent to 18 million tonnes, driven by increased production in the region's largest milk producer, Mexico. In South America, milk production expanded by 2.0 percent to nearly 82 million in 2020, driven by higher outputs in Argentina, Brazil, Chile and Uruguay, partially offset by a decline in Venezuela. In Argentina, milk production expanded faster than anticipated earlier due to improved pastures and internal and foreign demand. In Oceania, following a 2.5 percent contraction in 2019, milk output expanded by 1.1 percent to

[19]Yayli, B. and Kilic, I., 2021. Natural ventilation in dairy cattle barns.Engineering Sciences, p.67.
[20]Devi, M., Rahman, U.H., Weerasinghe, W.P.M.C.N., Mishra, P., Tiwari, S. and Karakaya, K., 2019. Future milk production prospects in India for various animal species using time series models. Indian Journal of Animal Research, 1, p.6.
[21]Roberts, I., Saunders, T., Spence, G. and Cassidy, N., 2016. China's evolving demand for commodities. In Structural Change in China: Implications for Australia and the World, Proceedings of a Conference, Reserve Bank of Australia, Sydney (pp. 107-158).
[22]Sattar, A., 2022. What is Holding Back Milk Production Potential in Pakistan?
[23]Robinson, S., 2020. Livestock in Central Asia: From rural subsistence to engine of growth? (No. 193). Discussion Paper
[24] https://ifcndairy.org/wp-content/uploads/2019/10/Dairy-Report_2019_extraction_for-marketing.pdf

31 million tonnes in 2020. After four years of declines, milk production in Australia rebounded by over 9 million tonnes, underpinned by good rains, improved pastures and increased fodder and feed availability. In Africa, milk production remained stable, at 49 million tonnes.

The available data show that there has been a gradual increment in milk production in Nepal. The total production of milk in FY 2020/21 A.D. was 2,479,899 MT comprising 1,419,412 MT (57.24%) from buffalo milk and the remaining 1,060,487 MT (42.76%) from cow milk. The trend shows increasing production in the past decade (Figure 1).

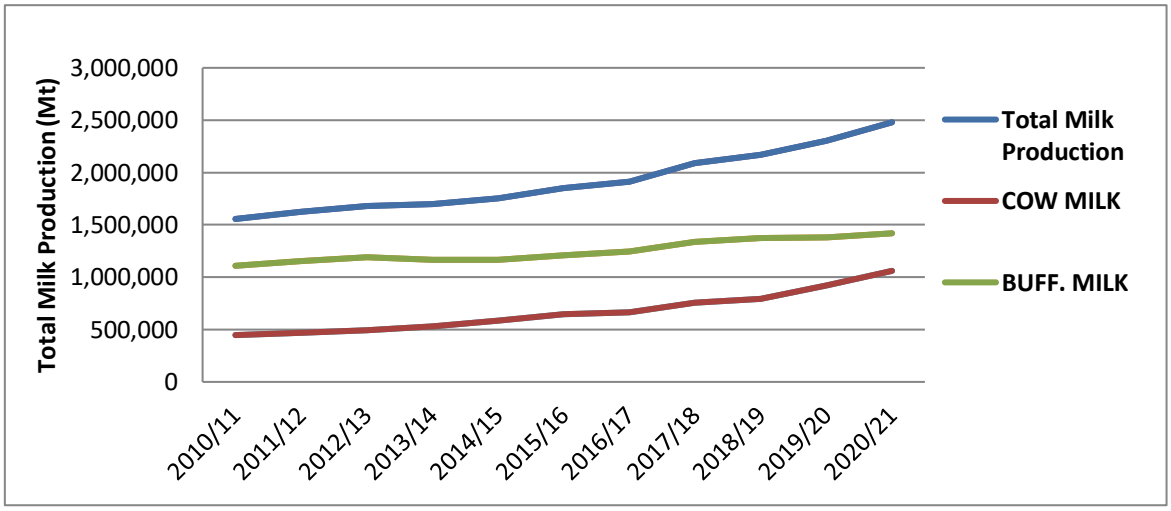

Figure 1. Production trend of milk in the last 11 years in Nepal

Globally, studies[25] forecast that this year, dairy cow milk production will increase by 1.4%, compared to the 3-year average 2019-2021 and a total of 156 million tonnes. It should reach 158 million tonnes by 2025. The number of dairy cows is expected to decrease from 20 million heads in 2022 to 19.6 million in 2025. Imports into China were up by 16% year-on-year in 2021. Since September, however, imports have been down 3%. In the US, rising milk prices are stimulating production once again, but the US milk cow herd will remain below year-ago levels until the second half of 2022.

2.4 Global cost of milk production

The average cost analyzed over all countries[26] was 38.4 USD/100 kg energy corrected milk (ECM). Energy Corrected Milk determines the amount of milk produced adjusted to 3.5%

[25]https://www.dairyglobal.net/industry-and-markets/market-trends/jump-in-global-dairy-prices-eu-2022-prices-to-rise/
[26]http://ijlr.org/issue/competitiveness-of-milk-production-global-scenario/

butterfat and 3.2% protein. The regions which fall in the range of 40-50 USD/100 kg ECM were Western Europe, North America and Asia. The Mid East and Latin America had average cost levels between 30-40 USD/100 kg ECM while the cost in Africa, CEEC and Oceania alter between 20-30 USD/100 kg ECM. The low-cost regions were some farms in South America; Central and Eastern Africa. The cost of well-managed farms in Western Europe was found in the range of 30-55 USD. While in the case of North America the cost of large farms varied between 26 USD/100 kg ECM for Idaho to 40 USD/100 kg ECM for New York. In India, the cost was in the range of 40 to 50 USD/100 kg ECM. In Oceania costs remained stable in Australia (32 USD) but decreased for New Zealand which reached 28 USD/100 kg ECM.

There has been a gradual shift down in the cost of milk production towards the 35 - 40 USD/100 kg ECM mark since 2012 in the major milk-producing countries[27]. This indicates market supply corrections and stabilization in prices in the medium and long run. There is wide variability in productivity and economic cost levels. Dairy development takes place in every country at different levels as they have huge variations in farm structure (number of dairy farms, average farm size etc.), cost and returns from the dairy enterprise. In the case of farm structure, India had the highest milk production in the world because of the highest bovine population in the world. But at the same time, the milk yield level in India was very low as compared to other countries like the US, Germany and China[28]. A declining trend was seen in several farms in most of the countries because of consolidation. The variation in the cost of milk production can be attributed to regional variations in feed cost, labour cost and other maintenance costs of different breeds across regions. In the case of a time series analysis of the cost of milk production in major countries, it was seen that the cost increased up to 2013 and thereafter exhibited a declining trend. While in the case of total cost analysis among major countries, New Zealand was found as most competitive as it had the smallest cost compared to other countries but when returns were considered then Brazil followed by India was found as most competitive. All the other countries highly depended on coupled subsidies to cover the total economic cost owing to low milk returns.

[27]Thorne, F., Gillespie, P.R., Donnellan, T., Hanrahan, K., Kinsella, A. and Läpple, D., 2017.The competitiveness of Irish agriculture.*Agriculture and Food Development Authority, Ireland*, p.124.
[28]Douphrate, D.I., Hagevoort, G.R., Nonnenmann, M.W., LunnerKolstrup, C., Reynolds, S.J., Jakob, M. and Kinsel, M., 2013. The dairy industry: a brief description of production practices, trends, and farm characteristics around the world.*Journal of agromedicine*,*18*(3), pp.187-197.

In the Nepalese context, the trend in the cost of milk production (Figure 2) per litreof milk showsa gradual increment, annually. The latest cost of production in Nepal was NPRs 56.32 per litre in the fiscal year 2077/78[29].

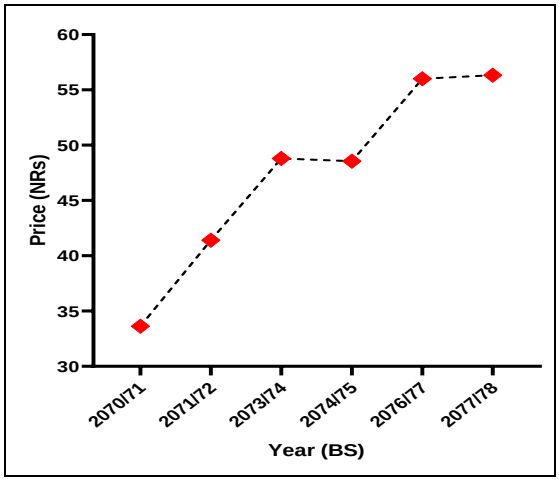

Figure 2. Trend of milk price in earlier years

(NDDB, 2021)

Secondary data collected from the MoALD, Nepal analysed for the total population of milking animals and the total milk yield at the district levels. The result is shown in Figure 3.

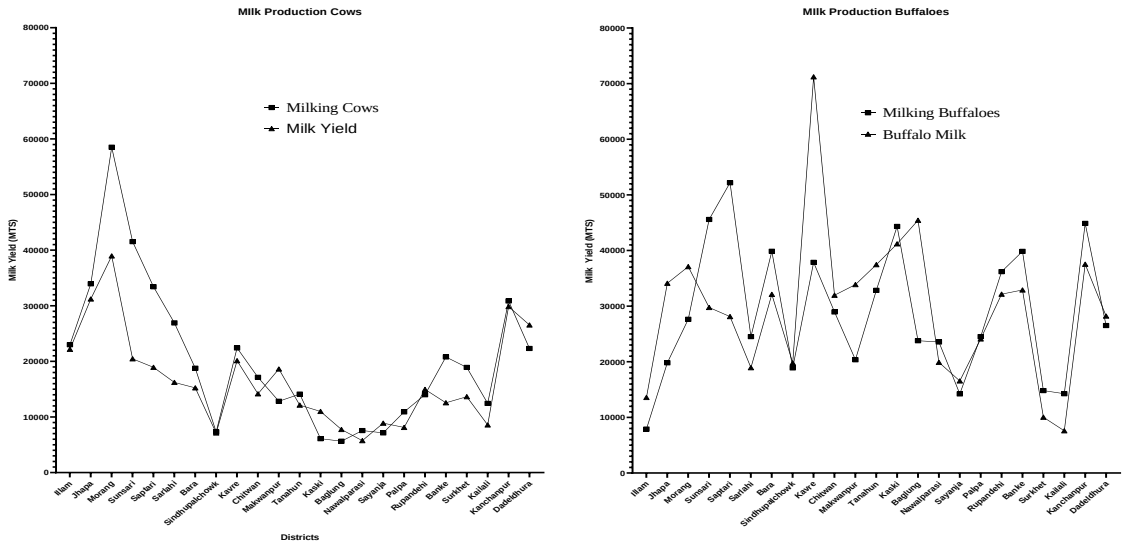

Figure 3. Total number of milk animals and milk production in the survey districts

(MOALD, 2018/19)[30]

[29]NDDB, 2021.Annual report for fiscal year 2020/21

[30]MOALD, 2019/20. Statistics of Nepalese Agriculture, MoALD, Singha Durbar, Kathmandu

From the above figure, it is seen that the average of cow milk to the total milk yield in the study districts was 36% and that of buffalo milk was 64%. In Syangja, the contribution of the cow was lowest at 14.5% and that of buffalo was highest at 85.5% whereas in Ilam the contribution of the cow was highest at 62% and that of buffalo was lowest at 38%.

2.5 Factors influencing thedairy farming

The profitability in dairying is irrational due to inefficient production and marketing practices.There is good potential to increase the production and marketing efficiency of milk animals by providing non-genetic and genetic improvements. The aim of ADS at achieving 1487 litres (1533kg) of milk per lactating animal in a lactating period by 2080/81 is short by around 437 litres i.e. 41.6% concerning the present productivity[31].Genetic factors i.e. purity of the breed, diseases like FMD, Mastitis and reproductive problems and non-genetic factors like farm management, feeding and maintenance costs, low quality of feed and products, utilizations of byproducts, pricing mechanism of milk, channels in market etc are the major causes for low economic efficiency in cattle/ buffalo rearing.Working out such inefficiencies in both production and marketing will help increase the share of livestock production in the income of farmers. Besides, every stakeholder would get an appropriate share of the profit and urban consumers will get a regular supply of quality milk at an appropriate price.

An overall constraint is that, while the cost of production will vary by location, market prices are setnationally by DDC, giving a natural advantage to some over others; being located closer to a pavedroad provides a natural advantage, such that private, cooperative and DDC led processing units to competefor these locations. Such competition can drive prices above the DDC minimum benchmark, providinga greater income for dairy farmers fortunate enough to be within reach of more than one processor.

Another constraint is that production costs have been increasing;reports indicate that farmers are using 78% straw, greenforage concentrates and grains for animal feed from their land which can improve yield andquality but also requires investment[32]. Many small-scale farmers are unaware of good hygienepractices, but they also purposefully adulterate their supply (by adding sugar and/or water) to try toimprove their income, which in turn can ruin the quality

[31]Lamsal, S., Subedi, D., & Kaphle, K. 2020. Buffaloes Production and Reproduction Efficiencies as Reviewed for Parity in Nepal. International Journal of Applied Sciences and Biotechnology, 8(1), 1–6. https://doi.org/10.3126/ijasbt.v8i1.27802

[32]Salem, H.B. and Smith, T., 2008.Feeding strategies to increase small ruminant production in dry environments.Small Ruminant Research,77(2-3), pp.174-194.

of all the milk once it is mixed in with others.To try and address this, more analyzers mustbe introduced at chilling/collection centres although thisis still not available everywhere.

2.5.1Breeds and breeding stock

In Nepal most common are the breeds of Jersey and Holstein Friesian. The indigenous local cattle or buffalo though hardy, yield a low volume of milk which is not suitable for commercial farmers. Study results revealed that in 2015, the milk yield was significantly highfor the improved breeds. Accordingly, the highest milk production 3173±55.2 kg was observed in pure Holstein cattle among the different breeds[33]. Onlyabout 5% of the cattle in Nepal are considered pure breeds, like Holstein and Jersey.Farmers, therefore, use AI to crossbreed Holstein and Jersey cattle with their local cattle toboost milk production. Studies have shown that the native hill cattle's blood level should not be lower than 25% to make effective use of resistantgenes to parasites and diseases prevailing in the cattle farming system of Nepal[34].

2.5.2Feeds and feeding

The availability of good quality as well as quantity forage is a major problem for dairy farmers. This has madethe dairy industry become more concentrated based than forage-based. Commercially produced concentratesare expensive and their use increases the cost of milk production and reduces profits. In many parts of thestudy areas, the availability of adequate amounts of forages is becoming a problem. April, May, October andNovember months are the feed scarcity period. During these months, straw and other poor-quality feed are fed to cattle. Milk production declines in this period due to low nutrient feed.The quality forage-based production system reduced the cost of milk production by reducingconcentrate feed by 35% to 45%[35].There has been a forage mission program focusing on the Forage Resource Centre(FRC) one in each district for the propagation of forage seeds, saplings, and slips which are the keystones for successful dairy farming[36].

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[33] U. Paneru , M. Sharma, M.R Kolachhapati and B. S. Shrestha. 2015. Evaluation of productive performance of cattle in dairy pocket area of Chitwan and Nawalparasi districts. J. Inst. Agric. Anim. Sci. 33-34: 207-212 (2015)

[34]https://www.researchgate.net/profile/MeghTiwari/publication/2619883209thNationalProceedingsofLivestockandFisheriesResearchNepal/links/60ee3ce216f9f313007f95f4/9thNationalProceedingsofLivestockandFisheriesResearchNepal.pdf#page=31

[35] S. Paudel, S.H. Ghimire and Y.R Pandeya. 2021. Cattle Research in Nepal: Current Status, Challenges and Way Forward. Proceedings of 12th National Workshop on Livestock and Fisheries Research in Nepal, 3-4 March, 2021

[36]B. Sharma. Milk marketing and dairy value chain development in Nepal in relation with climate resilience effort in the present context. Nepalese Veterinary Journal, 34: 144-151

There is excess green forage available during the monsoon period, but for theremaining six months, over the winter and spring, there is a lack of feed. In commercializedfarming situations, farmers compensate for shortages of forages with supplementation of expensiveconcentrate feeds. As concentrates are expensive, animals are not fed to their requirement whichincreases costs without a significant increase in production. This has serious implications forthe competitiveness of the local products against imported products and the sustainability oflivestock production systems

2.5.3 Animal health and husbandry

Infertility problem is severe mainly in crossbreds. Routine drenching and vaccination should be strictly followed against parasitic infestation and other infectious diseases. Mastitis is one of the major economic diseases of cattle mainly high-yielding cattle. The outbreak of different diseases like FMD, HS, BQ, mastitis, infertility, abortion,fascioliasis, and external parasitic infestation causes huge economic losses as well as decreased production and productivity[37].Infertility in cattle regardless of the breed is perhapsthe most limiting factor towards the dairy sector improvement. Likewise, the frequent occurrence of mastitis contributes to low quality & quantity of milk production[38]. There are national FMD control projects focusing on the vaccination of animals in the dairypockets of the country. HS and BQ vaccination are also regularly distributed by the district veterinary hospitals under the national scheme[39]. The focus should be given tothe use of sexed semen to reduce the problem of the male calf.Agro-vets are the major technical serviceprovider for farmers.Studies have shown that deworming has a positive influence on the fat and SNF composition of the milk[40]. Similarly, the other problems in dairy animal husbandry are the high number of low-productive cattle and lack of appropriate high-yielding breeds fordifferent eco zones, Infertility and male calf management and the high cost of productive animals.

2.5.4Market

There is no assured market for milk sales in hilly areas. There is a knowledge gap regarding productdiversification and value addition of dairy products. Only 15% of milk is sold through

[37] S. Paudel, S.H. Ghimire and Y.R Pandeya. 2021. Cattle Research in Nepal: Current Status, Challenges and Way Forward. Proceedings of 12th National Workshop on Livestock and Fisheries Research in Nepal, 3-4 March, 2021

[38]Annual Report, 2076/77. 2077. Animal Health Research Division, NARC, Khumaltar, Lalitpur

[39]B. Sharma. Milk marketing and dairy value chain development in Nepal in relation with climate resilience effort in the present context. Nepalese Veterinary Journal, 34: 144-151

[40] https://doi.org/10.1136/vetreco-2019-000380

formal marketingchannels[41].The dairy industry is said to be a process from "*grass to glass"* which passes through different channelsinvolving various actors. The marketing system for milk is predominantly informal and it is characterized bythe presence of several small-sized farmers, milk processors, milk/dairy shops, and vendors operating atdifferent stages of milk collection and distribution. In an informal system, individual farmers or contractorsare the main actors who directly deliver milk to the individual households/tea shops/sweet shops etc.Sales of a larger volume of milk via the informal sector imply that the milk quality is not standardized, the price is not regulated and the transportation is done in small batches, which would lead to the deterioration of the shelf life of the milk. So it is important that eh government policies bring such informal sector under legal scrutiny and jurisdiction.

2.5.5Value chain

The dairy sub-sector has a strong and established value chain linkage from production to theconsumption level in Nepal. Backward linkage for the farmers is comprised of para-vets, agro-vets,feed industry and suppliers, dairy resource centres, bank and financial institutions, insurancecompanies etc. helping milk production. Similarly, chilling centres, milk producer cooperatives,middle man, dairy industry, whole seller and retailer are the forward linkage, where numerouspeople of various disciplines have been getting employment opportunities.

Milk produced at the farmer level is collected at groups or cooperatives level where milk is chilledand transported to the processing industries for processing, product diversification andmarketing. Out of the total milk collection from the formal sector, the government-owned DairyDevelopment Corporation is collecting and processing 22% and the rest are from private dairies[42].The cooperative movement has been the milestone and driving force for milk marketing in thecountry. Despite decades of the cooperative movement and gradual shifting toward the formal milkmarketing sector, a large proportion of milk and milk products in Nepal continues to be marketedthrough the 'informal or unorganized sector'[43]. The informal sector comprising middlemen,private milk traders and direct sale from producer to consumer, still accounts for nearly twice themilk collected and marketed by the formal sector. Trends

[41]https://www.casaprogramme.com/wp-content/uploads/CASA-Nepal-DairySector-analysis-report.pdf
[42]https://nddb.gov.np/storage/uploads/fTcDLnLePusdxD3qGKLs2PZVBKSxJISPwtTNtXC2.pdf
[43] B. Sharma. Milk marketing and dairy value chain development in Nepal in relation with climate resilience effort in the present context. Nepalese Veterinary Journal, 34: 144-151

indicate that the informal sector willcontinue to play its dominant role in milk marketing in the foreseeable future[44].

2.5.6 Subsidy

National Dairy Development Board (NDDB) andCommunity Livestock Development Project (CLDP) implemented different activities to decrease the costof production particularly to reduce the feed cost, but it was not enough to bring about changes among thefarmers to streamline the grass to glass concept.Dairy sector subsidy and support/projects have been implemented by different government and non-governmentsector organizations in the dairy pocket areas, some successful examples of such projects are shown in Table1 below.

Table 1. Recent projects of the I/NGOs for the development of the dairy sector in Nepal

Donor	Project	Objective	Timeframe& Budget	Area
Heifer International	Feeding support tool development for enhancing dairy animal productivity for the improved livelihood of small holding dairy farmers	To increase household income and create improved livelihoods for small holding dairy farmers through the improvement of dairy animal productivity, particularly better-feeding management.	Oct 2016 – Jan2018&$129,958	Palpa, Arghakhanchi and Kapilbastu(Province 5)
HeiferInternational	Improvingdairy animalproductivityand farmers'incomesthrougheffectivecontrol ofmastitisdisease	Enhance dairy SHFs'livelihoods throughincreased incomefrom productivityimprovements thanksto effective mastitiscontrol.	Oct2016 – Jan2018&$129,142	Surkhet, Bardiya,Banke and Dang (Province 5 & 6)
PracticalAction	Dairy for Development in	Lower	Apr 2018–	Chitwan,Mak

[44]https://nddb.gov.np/storage/uploads/LQcxqKlCvgBPembtHFzxB8T3YV12ulGtKTGfn8oP.pdf

inpartnershipwithFORWARD -Nepal	Nepal	productioncosts to boost rural livelihoods byenhancing production techniques,strengthening value chains and improving the genetics andhealth of dairy cows to increaseproductivity.	Mar2021& $ 47567	wanpur andNawalparasi (Province 3)

The support and subsidy programs are concentrated indairy animal management, dairy animal purchase, shed improvement, dairyequipment/materials/utensils, dairy marketing and others.The government of Nepal (GoN) has provided a 75% subsidy on premiums for the insuranceprogram, which benefited dairy farmers[45].In 2017, the MoALD started the scheme of subsidy of one rupee per litre of milk[46]. In 2021, the state government of Province 1 has made an arrangement to provide a cash subsidy at the rate of Rs 2 per litre to the farmers who produce milk[47].To provide the subsidy and support, the providing agencies have developed guideline/operationalstrategies and most of the guidelines are compliantwith each other except for the donor-funded projects. It wasrealized that the guidelines prepared and administered by the donor-funded projects are more structuredand complicated as many formalities are kept in the selection, implementation, monitoring and evaluation ofsubsidy/support [48] . These guidelines [49] were reported to be complicated as the subsidy/support is towards the commercialization of dairy farming and the volume of the money is a bit high.

2.5.7Economic benefit

The government has not focused on ensuring security through insurance and soft loan to farmers- individuals or clusters. Farmers' friendly investment modality is still lacking to

[45] B. Sharma. Milk marketing and dairy value chain development in Nepal in relation with climate resilience effort in the present context. Nepalese Veterinary Journal, 34: 144-151
[46]https://thehimalayantimes.com/business/dairy-farmers-get-subsidy-rupee-per-litre
[47]https://www.newbusinessage.com/Articles/view/15468
[48]https://www.casaprogramme.com/wp-content/uploads/CASANepal dairy sectoranalysisreport.pdf
[49]https://nddb.gov.np/storage/uploads/GLtIwiH2Xv7l3YSTsmJSrjUqUYnT9VUkvrwb06LL.pdf

develop infrastructures like cold stores, laboratories, veterinary facilities, and milk diversification.Insurance and cooperative schemes were found to be the major risk management tools amonginsurers whereas informal sources (friends and relatives) and the sale of assets is the major riskmanagement tool among non-insurers[50]. Being not aware of facilities available after insurance could be some of the reasons for not joining cattle insurance schemes. The mathematical models reveal that cattlebreed, access to loans, income from livestock and number of cattle were positively significant factorsdetermining cattle insurance whereas household size, and the district were negatively significant[51]. Based onthe findings from the earlier study[51], programs to motivate farmers for rearing improved cattle breed, improving access of farmers to agricultural credit, and awareness generation programs regarding riskmanagement strategies would be welcomed to avoid economic loss among cattle rearing farmers.

[50]https://www.casaprogramme.com/wp-content/uploads/CASA-Nepal-DairySector-analysis-report.pdf
[51]Subedi&Kattel, Cogent Food & Agriculture (2021), 7: 1911422, https://doi.org/10.1080/23311932.2021.1911422

3. METHODOLOGY

3.1Primary data collection

Primary data was collected using two approached-a farmers' survey and a key informant interview (with the local people involved in the dairy business, public organizations, local level organizations or the milk collection cooperatives).For the survey, a purposive random sampling method was used to gather the survey data. All 24 districts have been selected to cover maximum geographical coverage and dairy potential regions. It will help to minimize the error. The districts included in the survey for data collection are shown in Figure 5below.

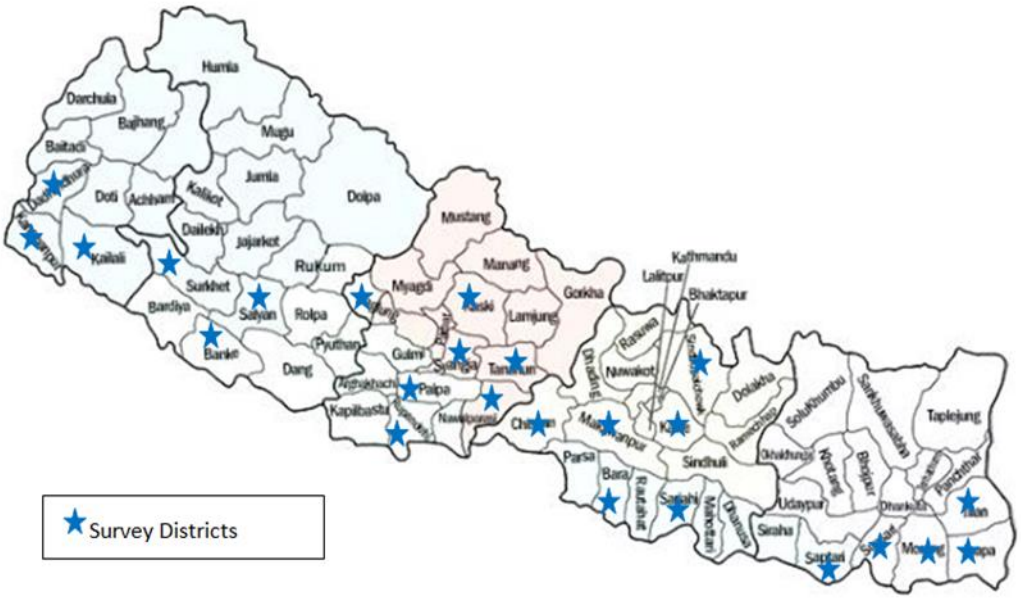

Figure 4. Districts (indicated by blue star) used for sampling survey of this study

3.2 Sample size

A good representative primary data was collected through the survey. For this, a purposive/stratified sampling method was applied for primary data collection.From among the selected districts, either one or two MPCs were selected as entry points and from each cooperative ten to twenty dairy farmers wereselected for the household survey. This number of selections depended on the availability of resources such as time, funds, and farmers' willingness to cooperate.

In each study district, DMPCs were contacted for the dairy farmers' database in that particular district. As per the nature of milk production capacity in the districts, farms were divided into three different categories as large-scaledairy farms, medium-scale dairy farms

and small-scale farms based on the criteria set by the Department of Livestock Service[52].The details of this guideline are as follows:

1. Small Scale Dairy Farm: A dairy farm with 5-10 high-yielding improved breeds of milking cows or 2-4 high yielding improved breeds of milking buffaloes.
2. Medium Scale Dairy Farm: A dairy farm with 11-30 high-yielding improved breeds of milking cows or 5-12 high yielding improved breeds of milking buffaloes.
3. Large Scale Dairy Farm: A dairy farm with more than 30 high-yielding improved breeds of milking cows or more than 12 high-yielding improved breeds of milking buffaloes.

A total of 599 respondents were interviewed in all 24 study districts of all 7 provinces. It includedpersonal interviews with 530 milk producer farmers,29 key informants and 40 individuals working in various capacities in the dairy cooperatives of the selected districts. The following table (Table 2) shows the sample size in detail.

Table 2. Sample size used for quantitative survey and collection of primary data

Province	District	Producer	KII	Cooperative	Total
Province 1	Ilam	48	2	2	52
	Jhapa	16	1	2	19
	Morang	21	1	2	24
	Sunsari	10	1	1	12
Madhesh	Saptari	21	1	2	24
	Sarlahi	21	1	2	24
	Bara	21	1	2	24
Bagmati	Chitwan	48	2	2	52
	Kavre	48	2	2	52
	Makwanpur	31	2	2	35
	Sindhupalchowk	20	1	2	23
Gandaki	Kaski	20	1	2	23
	Tanahun	20	1	2	23
	Nawalpur	20	1	2	23
	Baglung	20	1	2	23
	Syangja	20	1	2	23
Lum bini	Rupandehi	45	2	2	49
	Banke	10	1	1	12

[52] □□□ □□□□ □□□□□,□□□□ □□□□□□ □□□□□□□□□ □□□□□□□□□□□ □□□□□□□□□ □□□□

	Palpa	20	1	1	22
Karnali	Surkhet	10	1	1	12
	Salyan	10	1	1	12
SudurPaschhim	Kailali	10	1	1	12
	Kanchanpur	10	1	1	12
	Dadeldhura	10	1	1	12
Total	**24**	**530**	**29**	**40**	**599**

3.3 Conduction of survey

The survey and subsequent data collection were done electronically using hand-held electronic devices. For this purpose, the survey format was designed in the EpiCollect Platform[53]. The format was subsequently downloaded into personal handheld mobile devices via the EpiCollect application. The data enumerators were granted access to the application format by the project leader and an orientation class was conducted virtually for all the enumerators until they felt comfortable using the application and the questionnaire format. All the enumerators were asked to test the format with three farmers before collecting the actual data. These three data sets were not included in our analysis. That way, it was made sure that all the enumerators could work comfortably with the software to meet the desired goal. The detail of the questionnaire format used for data collection is given in Annex 1 and Annex 2.

3.4 Quality control

Quality of data collection, data entry, output production etc. were ensured basically by adopting measures to minimize non-sampling errors as well as entry and management of data as briefly outlined below.

- Experienced technical enumerators were recruited to work in data collection.
- Questionnaires/checklists were pretested among the dairy farmers of Samudratar, in Nuwakot.
- One day virtual orientation was organized for the enumerators on using the mobile application for data collection.
- The collected data was shared among the study team,weekly, to review the content and suggest any changes to the enumerators as necessary.

3.5 Data curation and analysis

[53]https://five.epicollect.net/

Once the data was entered intothe application software and uploaded to the central server, the team leader could access all the collected data and run downstream analysis. At first eh data were curated for accuracy, uniformity and reliability. As the software cannot distinguish between the errors in the spellings and punctuations, these minor curation greatly increased the machine readability of the data and thus expedited the analyses. The data was analyzed in descriptive statistics using MS Excel and further economic analysis was made in the SPSS platform on a Windows machine. The basic assumptions and the estimation arrangements used for the data analysis are presented in the subsequent sections.

3.6 Estimation arrangements

The total cost of production was calculated using variable and fixed costs. The variable cost of milkanimals included expenditures incurred on feed (readymadefeed, dhuto, bran, bhus choker, green grass, straw and hay silage), labour, vitamin & calcium, medicine, vaccine, breeding, technical expenses, tractor fuel, seed & manure for grass, water, electricity, communication and others miscellaneous expenses. The fixed cost comprised of depreciation on animal and fixed assets (shed and machinery) and interest on fixed capital. These costs were taken on an average monthly basis.

The depreciation rate was calculated at 10% per year based on the assumption of a 10-year productive life for dairy animals. Similarly, depreciation rates for other fixed assets were established at 2.5-5% (shed) and 10% (machinery and equipment) respectively. The annual interest rate on fixed capital, such as the value of an animal or a cattle shed, was set at 12%. Based on the current wage rate in the area, the value of family work was calculated.The costs per animal were calculated based on the total number of adult animals on a farm using the following formulae[54]

SC = TSC × MA/ TA (1), where

SC = the shed cost per milch animal

TSC = Total shed cost in NPRs

MA = Milking animals

TA = Total animals

In the study areas, fodder is the major input for livestock rearing. The cost of fodder was calculated based on per acre price at the prevailing rate in the study area and the share of milk

[54]Ahmad, B., M. Ahmad and M.A. Chaudhry. 1996. Economics of Livestock Production and Management. Agric.Social Sci. Res. Centre, Univ. of Agric., Faisalabad. 89-90.

animals can be derived from the total cost of green and dry fodder by using the following formula.

CMA = TCF × MA/TA (2), where

CMA = Cost of green and dry fodder fed to milking animals in NPRs

TCF = Total cost of green and dry fodder fed to livestock

MA = Milking animals

TA = Total animals

Cost of milk production = Totalcost /ΣMP, where

Totalcost = Total Variable Cost + Total Fixed Cost

ΣMP is the sum of milk production

Milk production per month was calculated based onthe total milk yield per lactation period of the animal reared. Marketed surplus milk per month and respective average prices received were taken to calculate gross income from milk per month. Other incomes from FYM (Farm Yard Manures), sales of animals and other incomes were computed. For milk production total yield per household per lactation of wet animals was computed with the respective price received by the household and those who did not sell the milk at the prevailing price in the villages and used it for home consumption were taken into account to arrive at the gross income from milk production. An average animal was supposed to have produced 13.6 kilograms of fresh dung per day. As in some villages, there was a common practice to make dung cake to be used as fuel, thus the income from farmyard manure was computed in terms of dung cakes. A total number of dung cakes produced per day and multipliedbythe average village price of dung cake. Production cost per litreof milk, monthly milk yield, gross income and net income were computed using the formulas below:

Cost of milk production per litre = Total cost /TM, where

Total cost = Total cost in a parturition interval (lactation + dry period)

Tm= Total milk yield in a lactation period

Average monthly milk yield = (Total yield /PI), where

Total yield = Total milk yield in a lactation period

PI = Parturition interval in months

Monthly income from milk = Average monthly milk yield * Average milk price

Average Monthly Net Income= Monthly Gross Income - Monthly Gross Cost

Milk production is dependent on multiple variables for example health, nutrition, age, breed and environmental influence. Valuation of the influence of these variables is beyond the scope of this work, so for the sake of the calculations, it has been assumed that their influence is equal in all regions and scales of production which may not always be the real representation of the field.

Similarly, the cost to be incurred on the milk animals during their dry period also has to be defrayed by the income from the ilk produced during the lactation period; the calculated cost of production may be slightly higher in case it is calculated based on only the lactation period. Additionally, all of the calculations herein are based on the number of animals per farm (large, medium and small) not on the volume of milk produced. For example, a farm with only two cows may be producing more milk than a farm with 10 cows where eight of the cows are non-milking. But on the farm with 10 cows, the income made by the milk of two cows should cover the expenses of all the cows whereas,on the farm with two cows, milk produced from both of these will cover the cost incurred for both of these. So these are two different scenarios, where even if the numbers of milking animals are the same, the cost of production will be different. This discordance has to be taken into consideration when interpreting this report.

The total economic cost of a dairy enterprise includes cash cost, depreciation and opportunity cost. If the opportunity cost of owned resources is not included in the cash cost calculation the analysis will tell about the future competitiveness valid in the short to medium term only. In the longer term, adjustment within the sectors will be a reality which will be dependent on relative resource use. Hence, total economic cost which includes imputed charges for owned resources was considered to examine the longer-term outlook for the competitiveness of the sector. The various sources of income are milk returns, cattle returns, and coupled and decoupled subsidies out of which milk and cattle sales form the major portion.

The cost of production is highly variable and cannot be expected to follow a certain pattern or trend. In this study, there are 24 districts, where farming is at various levels and scales. Animal health, nutrition, and husbandry are all responsible for the total yield which will vary all year round. So to make an accurate estimate for his we used three-time frames for milk yield. Our analysis is based on textbook-approved academic formulas and methods. Several dozens of publications have been made around the globe using the same method and formulas

that we have used. So rather than just relying on the classical method of total cost divided by total income, we have considered several other parameters such as lactation interval, lactation length, and productive life of animal just to name a few to come to the conclusion that we have made.

However, there are certain limitations to this study. The data we collected was based on the 'memory and recall' of the farmers. As we all are aware that the farmers generally do not keep a record of the expenses they make, we cannot claim the veracity and accuracy of the data but as the analysis was for their purpose, we strongly believe that the data they shared with us was true for the purpose we wanted, the only method to minimize this is to preselect the farms.

4. RESULT AND DISCUSSION

The literature review suggests that there are 7458885 cattle and 5257591 buffaloes in Nepal. Out of these, there are 1166156 (16%) milking cows and 1635492 (32%) milking buffaloes. Terai has the highest number of both cattle and buffalo (45% cattle and 48% buffalo) followed by hills (43.5% cattle and 45.5% buffalo) and the least in the mountain at 11.5% cattle and 6.5% buffalo[55]. An NLSIP report states that the average milk production per lactation is 450 and 850 litres for the local breed of cow and buffalo.For the cross-bred, it is 1650 and 1500 litres respectively[56]. The productivity is far below the average due to many inherent and external constraints including poor genetic potential, inappropriate feeding and health care management. There is seasonality in milk production in the country, leading to flush season and lean season. The shortage of fluid milk is more severe during the lean season (March to August).

4.1 Farmtypes

Among the surveyed participants, half of the respondents were cattle farmers whereas, among the remaining half, there wasanequal number of buffalo and mixed farmers (Figure 6).

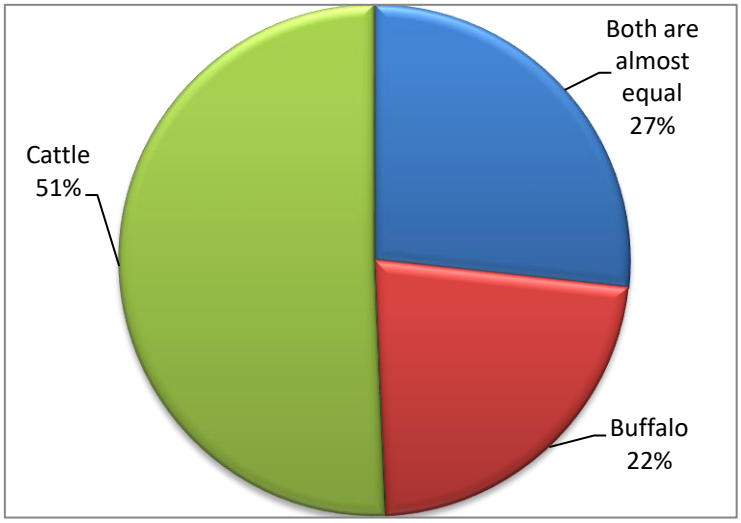

Figure 5. Types of dairy animals housed

4.2 Animal number

In cattle-only farms, the average number of milking animals was 4. Among the animal types, the average number of crossbred milking animals was four and the local breed of animal was one. Similarly, the average number of non-milking animals was two. Non-milking crossbreds

[55]https://moald.gov.np/wp-content/uploads/2022/04/Statisticalinformationon Nepalese agriculture2076/772019-20.pdf

[56]NLSIP, 2020.Buyers' Assessment on dairy sector in NLSIP working districts. (http://www.nlsip.gov.np/english/)

averaged two per household while the locals averaged less than one.In terms of breed, the average number of Jersey was three, and the average number of HF, local cows, and local cows was two.

In farms with buffaloes only, the average number of milking animals was 5 per household. Among the buffaloes, the average Murrah breed was four, that of local was one and the crossbreds was three per household. The number of non-milking buffalo averaged 1 household.

In mixed farms, the number of milking animals averaged 8 per household. The crossbreds averaged 6 and the locals averaged 2 per household. The average number of non-milking animals was 3.

4.3 Cost of production (per animal per month)

The overall total cost of livestock producers was 7660.8 NPRs per adult animal per month. The cost of livestock rearing was lowest in Lumbini province (5853) and highest in Karnali province (9140.67), details are given in Table 3.

Table 3. Overall total cost of livestock producers

Province	Total Fixed Cost	Total Variable Cost	Total cost
1	703.4	5921.5	6625
Madesh	658.77	7357	8015.7
Bagamati	1048.1	7680.23	8728.34
Gandaki	896.2	7114.5	8010.75
Lumbini	443.3	5409.9	5853
Karnali	697.1	8438.25	9140.67
SudurPaschim	708.8	6543.5	7252.3

(Farmer Survey, 2022)

4.4 Cost of production (per milk animal per month)

The most important cost item was nutritional costs accounting for (64%) of total costs, followed by labour cost of 825.34(9.32%), animal costs (6.58%), vitamin& calcium (3%) and shed (2.97%) of the total costs.Table 4 shows the average variable costs, average fixed costs and average total costs for large, medium, and small-scale farms.

The variable costs per adult milk animal were 6972.47, 7543.11 and 8961.65 NPRs respectively for different scales of operation. The overall variable cost of livestock producers was 7825.74 (88.41%)NPRs per adult animal.

The fixed costs per adult milk animal were NPRs 1286.96, 1085.6, and 705 respectively, and the overall fixed cost of livestock producers was NPRs 1025.87 (11.6%)per adult animal.

The total costs per adult milk animal were NPRs 8259.4, 8628.71, and 9666.7 respectively, and the overall total cost of livestock producers was NPRs 8851.62 per adult animal.

Table 4. Cost of production (NRs) per animal per month

Particulars	Scale of Operation			
	Large	**Medium**	**Small**	**Overall**
Variable Costs				
Commercial Feed	1519.66	1791.23	2050.37	1787.1(20.2%)
Dhuto/Bran	760	1049.83	1660.57	1156.8(13%)
Bhus/Choker	1162.2	1321.95	2032.23	1505.46(17%)
Vitamin/Calcium	299	320.39	190.91	270.1(3%)
Medicine	317	287.69	143.97	249.55(2.82%)
Vaccine	58.28	39.97	48.08	48.78(0.55%)
Breeding	159.47	111.67	119.07	130(1.47%)
Green grass	250.29	105.25	122.62	159.39(1.8%)
Straw	981.57	999.33	1159.48	1046.79(11.83%)
Hay/Silage	21.23	12.2	6.667	13.37(0.15%)
Labor	723	840	913.02	825.34(9.32%)
Technical Expenses	118.59	66.83	55.73	80.38(0.91%)
Tractor fuel	142.6	67.6	45.5	85.23(0.96%)
Seed/Manure for grass	148.68	122.76	86.225	119.22(1.35%)
Water/Electricity	118.97	156.39	76.13	117.16(1.32%)
Communication	22.45	33.01	10.81	22.1(0.25%)
Others	169.48	217.01	240.27	208.9(2.36%)
Total Variable Cost	***6972.47***	***7543.11***	***8961.65***	***7825.74(88.41%)***
Fixed Costs				
Shed Cost	350.2	230.32	209.26	263.26(2.97%)
Animal	702.615	657.88	386.84	582.44(6.58%)
Machineries & Equipments	57.54	52.35	32.96	47.62(0.54%)
Interests	14.2	5.25	0	6.48(0.073%)
Lease	162.4	139.8	76	126.1(1.424%)
Total Fixed Cost	***1286.96***	***1085.6***	***705***	***1025.87(11.6%)***
Total Cost (A+B)	**8259.4**	**8628.71**	**9666.7**	**8851.62 (100%)**

(Farmer Survey, 2022)

4.5 Cost of production and farm type

Table 5 shows the average variable costs, average variable costs and average total costs for farmers raising cattle only, buffalo only, or both. The variable costs per adult milk animal were NPRs 7218.32, 8057.35, and 8201.66 respectively, and the overall variable cost of livestock producers was NPRs 7825.74per adult animal.

The fixed costs per adult milk animal were, NPRs 893.17, 1152, and 1032.95 respectively, and the overall fixed cost of livestock producers was NPRs 1025.87 per adult animal.

The total costs per adult milk animal were NPRs 8111.3, 9209.42, and 9234.62 respectively, and the overall total cost of livestock producers was NPRs 8851.62per adult animal.

Table 5. Cost of production and farm types

Particulars	Farm Type			
	Cattle Only	Buffalo Only	Mixed	Overall
Variable Costs				
Commercial Feed	1698.35	1800	1863	1787.1(20.2%)
Dhuto/Bran	1046	1178.3	1246.1	1156.8(13%)
Bhus/Choker	1462.1	1521.8	1532.5	1505.46(17%)
Vitamin/Calcium	190.3	314	306	270.1(3%)
Medicine	219.3	258.8	270.5	249.55(2.82%)
Vaccine	31	65.36	50	48.78(0.55%)
Breeding	104.5	161	124.5	130(1.47%)
Green grass	130.22	181.95	166	159.39(1.8%)
Straw	1007	1067.5	1065.875	1046.79(11.83%)
Hay/Silage	14.37	13.14	12.6	13.37(0.15%)
Labor	792	799.13	884.9	825.34(9.32%)
Technical expenses	81.5	89.65	70	80.38(0.91%)
Tractor fuel	55.18	83.1	117.4	85.23(0.96%)
Seed manure for grass	100.7	124.5	132.47	119.22(1.35%)
Water/Electricity	90.3	127.18	134	117.16(1.32%)
Communication	20	20.79	25.6	22.1(0.25%)
Others	175.3	251.15	200.22	208.9(2.36%)
Total Variable Cost (A)	***7218.32***	***8057.35***	***8201.66***	***7825.74 (88.41%)***
Fixed Costs				
Shed Cost	240.9	282	267	263.26(2.97%)

Animal	491	679.5	577	582.44(6.58%)
Machineries &Equipments	35.4	64	43.5	47.62(0.54%)
Interests	5.6	7.7	6.2	6.48(0.073%)
Lease	120.27	118.87	139.25	126.1(1.424%)
Total Fixed Cost (B)	***893.17***	***1152***	***1032.95***	***1025.87(11.6%)***
Total Cost (A+B)	**8111.3**	**9209.42**	**9234.62**	**8851.62 (100%)**

(Farmer Survey, 2022)

4.6 Incomeper animal per month

According to the data obtained and analyzed(Table 6), the average milk yield per lactation per milk animal was 1600, 1525 and 1400litres for the large, medium and small scale of operation respectively, and on an overall basis,the average milk yield per day per adult milk animals was estimated to be 1508.3litres.

Table 6. Average milk yield per day

Particulars	**Scale**			
	Large	**Medium**	**Small**	**Overall**
Milk yield per lactation	1600ltrs	1525ltrs	1400ltrs	1508.3ltrs
Income from milk per month	14777.6	13671.63	12373.2	13594.31
Other income	597.64	575.73	565.34	579.57
Gross Income	15375.24	14247.36	12938.54	14173.9
Net Income (gross income-gross cost)	7115.84	5618.65	3271.84	5322.3

(Farmer Survey, 2022)

The gross income of large, medium and small farmers wasNPRs 15375.24, 14247.36and 12938.54, respectively and on the overall basis, gross income was NPRs 14173.9.On an overall basis, the net income from livestock production wasNPRs 5322.3.

4.7 Cost of production and returns

According to the data obtained and analyzed (Table 7), the cost per litre milk per milk animal was NPRs 51.62, 56.6, and 67.83 for the large, medium and small scale farms respectively. The overall cost per litre milk per milk animal was NPRs 58.7.

The average price received per litreof milk was NPRs 92.36, 89.65, and 88.38 for the large, medium and small-scale dairy farms respectively while the overall average price per litreof milk was NPRs 90.13.

The average margin per litreof milk was NPRs 40.74, 33, and 20.55 for the large, medium and small-scale dairy farms respectively and the overall average margin per litreof milk was NPRs 31.43.

Table 7. Cost of production and returns

Particulars	Scale			
Cost incurred in	**Large**	**Medium**	**Small**	**Overall**
Production cost (NRs/litre)	51.62	56.6	67.83	58.7
Gross price received for milk sold per litre	92.36	89.65	88.38	90.13
Margin per litre milk	40.74	33	20.55	31.43

(Farmer Survey, 2022)

4.8 Mode of selling and price fixation

Continuous development in the dairy sector has led to a shift in dairy rearing practices with improvedcross-bred cows slowly replacing buffalos and local cows. The 1980s witnessed this change in thefarming system in Nepal as farmers realized the high cost of maintaining buffaloes despite their high-fatcontent and the lack of high-yielding cows which entitled them to receive lower rates for their milk. The mixing and selling of cow and buffalo milk made it almost impossible to fix different rates for eachkind of animal as it was practically impossible to differentiate between the two types of milk under fieldconditions. This gave rise to a need for a more scientific method for the payment of milk, which gave rise to the dual-axis payment system. This method was based on the fat and SNF content of the milk. A minimum level of fat (3%) and SNF (8%)was fixed. Also, this system was justified because the payments were made on the amount of total solid(fat and protein) present which is co-related with the yield of the milk products that can be derived fromit. This method is being used to date.

Duringthe course of the survey, three modalities of price fixation for the raw liquid milk were observed (Table 8): (1) based on Fat, (2) based on fat/SNF, and (3) through mutual agreement between buyer and seller. Unlike the western countries, there is no system of pricing based on energy-corrected milk (ECM) in Nepal.

Table 8. Percentage of farms using different modes of price fixation

Particulars	Small	Medium	Large	Overall
SNF only	0	0	0	0
Fat only	21%	51%	60%	27.40%
SNF & Fat both	42%	41%	27%	41.23%
Mutual agreement	37%	8%	13%	31.35%
Total	100	100	100	100%

(Farmer Survey, 2022)

DDC and Private Dairies purchase their milk from the co-operatives based on Fat, SNF and TS. They also pay for the TS to enable the co-operatives to manage the operational and administrative costs. Co-operatives purchase milk from their members and non-members on the same fat and SNF basis. However, there are a lot of cooperatives that pay the farmers based onthe fat only. This practice is common in the areas in Kavre and Tanahu where the dairy animals consist mostly of buffalos and buffalos have higher fat content and low SNF.

4.9 Price and channel of sales

The obtained data were analyzed for the different modes of sales of raw milk and the variation of the price therein. The results showed that three distinct channels of selling the produced milk were observed, as given below.

Channel 1: Producer to Buyer

Channel 2: Producer to Cooperative

Channel 3: Cooperative to Buyer

Channel 4: Cooperative to Dairy

The variation in the transaction price among these channels of sales was estimated. The results showed that the highest price per litre of raw milk was observed in Channel 3 (NPRs 83.01) followed by Channel 1 (NPRs 82.8), Channel 2 (NPRs 81.1) and Channel 4 (NPRs 78.9). There was variation in the price when evaluated for the scale of operation of the dairy farms as given below (Table 9). Similarly, on average, large-scale farmers received a higher price (NPRs.92.36), followed by medium-scale producers (NRs.83.65), and small-scale producers (NPRs.77.36). This shows that the higher the production investment, the higher the price received. The price received by farmers on average was NPRs. 79.05.

Table 9. Channel of sale, price of milk and scale of operation

Scale	Channel 1	Channel 2	Channel 3	Channel 4	Average
Small	80.4462	83.4221	80.9462	78.6165	77.38
Medium	87.2288	71.6768	86.9939	78.0900	83.65
Large	99.4000	82.5385	98.6364	91.4286	92.36
Overall	82.7928	81.0793	82.8024	78.9500	79.05

(Farmer Survey, 2022)

Following are additional benefits provided by the cooperatives to their members in addition to milk collection and distribution:

- The co-operatives also share some portion of the amount received for TS with the member farmers.The member farmers are entitled to the bonus from the profit made by the co-operatives.
- The co-operatives also provide the farmers with other facilities like loans, cattle insurance, and other inputs such as feed and medicine supply, AI services, and veterinary services at a subsidized cost.
- Some cooperatives do strong bargaining with private dairies to get a higher price than DDC.
- They also accept technical/financial or managerial and material support from private dairy to improve the quantity and quality of milk and provide such private dairies with a subsidized rate for raw fresh milk.

The current study was done in the predefined districts as selected by the NDDB. Unlike the past years, some of the districtshave been repeated in this study while some are new districts. The cost of milk production is a highly variable output depending on various innumerable factors. To increase the accuracy and repeatability of these kinds of studies, the districts, farmers and cooperatives must be preset and they need to be studied for a long period. For example, one farmer in Ilam could have a large piece of self-owned land with lots of tree fodder and forages for the animal. At the same time, another farmer that too in Ilam could have less land and depend much on the concentrate feeding for milk production. Now, this would inevitably cause a difference in the cost of milk production. And if every year, the forage-based cattle farmers are included in the survey, the cost of production would be lower than the current one. In this year's survey, the farmers we included were mostly based on forage for dairy production. The use of commercial bagged feed was used only by large scale highly intensive dairy farmers.

Due to the COVID crisis of the last year, most of the farmers were found to keep only a few milking animals thus incurring less cost than in previous years in the feed and other variable costs. There is no significant change in the overall cost price of milk production this year as compared to the last year.During the COVID pandemic, many of the migrant workers returned to their homes and had nothing to do, they engaged in the kitchen garden, rooftop farming and livestock rearing as seen during the farmers' survey. This increased the availability of farm labour and since they had no other work, they did not include their opportunity cost in the farm expenses which as contributed to not having a significant increase in the cost of production for this year. On the other hand, associated impacts of COVID could have increased the demand for milk and milk products but as transportation was limited, the local produce might have fetched a premium price which was a transient effect of the COVID pandemic.The country's shutdownhas caused a loss of about 80 percent, amounting to $30 million, in the privately-owned dairyindustry, due to a fall in consumption and transport disruption[57]. The market has contractedsharply due to the closure of restaurants, hotels and food outlets, and the massmigration of people from urban to rural areas has directly impacted the livelihoods of 0.5million farmers and 10,000 staff that depend on the industry for employment. The difficultyin selling dairy products because of a limited period of market opening has further increasedloss as they are perishable, and cows and buffaloes need to be milked whether there is amarket or not.

During the farmers' survey, it was interesting to note that in some areas, farmers started cultivating more forage crops than food crops. They opined that the cost of buying the forage crops was much higher than the cost of buying food items from nearby Indian border cities because the demand for forage was high while the demand for food items was generally static. So the farmer changed their cropping strategy for minimizing the cost of milk production. Though not in shown and analyzed in our study, the impact of health and fertility is quite a challenge in Nepalese dairy animals. For example, study reports by NARC [58] revealed that more than 25% of dairy animals are affected with Brucellosis, Leptospirosis, Tuberculosis or Neosporosis (either singly or in multiple infections) thereby causing a significant loss in milk yield. Similarly, sub-clinical mastitis is also another major factor contributing to the yield loss in Nepalese dairy animals, especially cows. The farmers are

[57]https://doi.org/10.3126/md.v23i2.35825
[58]Annual Report, 2021. National Animal Health Research Centre of NARC, Khumaltar, Lalitpur

generally unaware of the loss contributed by these kinds of unseen problems but these will have a chronic depreciating effect on animal health and productivity.

The research[59]findings suggest that this pandemic has heavily affected the dairy industries in other countries like both China and the United States through similar mechanisms, such as decreased farm-gate milk prices, disruption and difficulties of moving milk within the supply chains, worker shortages, increased production costs, and lack of operating capital. There were also significant differences in the affecting mechanisms between the two nations, including transportation difficulties from widespread road closures and a significant reduction in holiday sales of dairy products in China, and the shutdown of many dairy processors in the United States due to the closing of schools, restaurants, and hotels. While government financial reliefs are highly needed to help many dairy farms and processors survive this pandemic in the short term, the dairy industries and governments need to work together to develop long-term strategies and policies to balance the industries' efficiency and flexibility, product specialization and diversification, supply chain integration and local food systems, and market mechanisms and policy regulations and interventions. While the scale of operation in the country is largely minuscule, similar impacts have been felt and reported by the farmers during the data collection.

The farmers' survey also revealed that the major limiting factor in the dairy industry was the availability of feeds and feeding resources and the accessibility to road services for smooth and timely transportation of milk to the distribution centres. The respondents also told that the chances of mastitis in high-yielding cattle were very high as compared to the buffaloes so novel technologies for mastitis prevention are needed. However, upon inquiring about the application of teat dipping technology for mastitis prevention, the farmers felt that the technology is not user-friendly and cumbersome to undertake.

The farmers also replied that the dairy business is good and will increase in scope in future because the demand for milk will never decrease. Similarly, dairying is a good source of side-business for many people in the peri-urbanareas, the demand is ever-increasing and this is a daily use commodity. On the other hand, some farmers opined that dairying is not profitable because milk is a highly perishable commodity so cannot be stored for a long time and needs prompt dispatch to the chilling centres. Similarly, the current increase in the commercial bagged feeds and the decrease in the availability of land for forage cultivations are also

[59]https://doi.org/10.1016/S2095-3119(20)63443-8

putting dairy farming in jeopardy. Moreover, with the increasing intensity of farming from extensive farms to highly intensive farms, the investment has also increased a lot and the animals have themselves become more fragile than they were in the past so health and breeding problems are more common these days than in the past. Similarly, in the milk trade too there were some defects as responded by the key informants. Firstly the farmers do not always bring fresh milk for sale; they sometimes brought the milk of the previous day which could potentially damage the entire collection of milk. Secondly, the farmers do not follow a good system of hygiene and cleanliness. The milk is brought into the collection centres in every possible kind of vessel. The farmers are not always paid a uniform price so they are unwilling to bring milk for sale to the cooperatives of the chilling/collection centres. Seasonality of milk production was also a major limiting factor in the milk and dairy trade.

Another study[60] indicates that the pandemic has been perceived as a series of episodes affecting the sector from both the demand and supply sides. The waves of the COVID pandemic have impacted the sector differently depending on regions and countries' trade profiles, relative resource scarcity, per capita income, and market structure. However, in the last year, the sector has mostly recovered from the shock.

[60]https://doi.org/10.1016/j.agsy.2021.103177

5. CONCLUSION

The current study was done in the predefined districts as selected by the NDDB. Unlike the past years, some of the districts have been repeated in this study while some are new districts. The cost of milk production is a highly variable output depending on various innumerable factors. To increase the accuracy and repeatability of these kinds of studies, the districts, farmers and cooperatives must be preset and they need to be studied for a long period. However, based on our current analysis and results, some conclusions and recommendations have been made.

Primary data was collected using two approached-a farmers' survey and a key informant interview (with the local people involved in the dairy business, public organizations, local level organizations or the milk collection cooperatives). A total of 599 respondents were interviewed in all 24 study districts of all 7 provinces. It included personal interviews with 530 milk producer farmers, 29 key informants and 40 individuals working in various capacities in the dairy cooperatives of the selected districts. The survey and subsequent data collection were done electronically using hand-held electronic devices. The data was collected, curated and analyzed for descriptive statistics using MS Excel and further economic analysis was made in the SPSS platform on a Windows machine.

Among the surveyed participants, half of the respondents were cattle farmers whereas, among the remaining half, there was an equal number of buffalo and mixed farmers. In cattle-only farms, the average number of milking animals was 4. In terms of breed, the average number of Jersey cows was three, and the average number of HF cows, local cows, and local cows was two. In farms with buffaloes only, the average number of milking animals was 5 per household. Among the buffaloes, the average Murrah breed was four, that of local was one and the crossbreds was three per household. The number of local breeds of cows and buffaloes is reported to be decreasing at an alarming rate. This may in the future lead to the extinction of the local genetic resources and total replacement of the dairy hers with exotic breeds.

The average total cost of livestock producers was NPRs 8851.62 per adult animal per month. The cost of livestock rearing was lowest in Lumbini province (NPRs 5853) and highest in Karnali province (NPRs 9140.67). According to the data obtained, the most important cost item was nutritional costs accounting for (64%) of total costs, followed by labour

costs(9.32%), animal costs (6.58%), vitamin& calcium (3%) and shed (2.97%) of the total costs.

Low yield, coupled with difficult terrain and high mount of variable as well as the fixed cost has contributed to the increased cost of livestock rearing in the Karnali province. Unlike in the past when the eastern region of the country was a steeply growing region for milk production, this year it was found that Lumbini province has a good growth rate and thus the lowest rearing cost. The road access, availability of techno-commercial services and extension of the market could have contributed to this lower cost in the province.

On the scale of operation, the variable costs per adult milk animal were NPRs 6972.47, 7543.11 and 8961.65 respectively for large, medium and small scales of operation. The all-scale average variable cost of livestock producers was NPRs 7825.74 (88.41%) per adult milk animal. Similarly, the fixed cost per adult milk animal per month was NPRs 1286.96, 1085.6, and 705 respectively for large, medium and small scales of operation. The all-scale fixed cost of livestock producers was NPRs 1025.87 (11.6%) per adult milk animal. In the same manner, the total cost per adult milk animal was NPRs 8259.4, 8628.71, and 9666.7respectively for large, medium and small scale operations. The all-scale average total cost of livestock producers was NPRs 8851.62 per adult animal.

For cattle only, buffalo only and mixed farms, the variable costs per adult milk animal were NPRs 7218.32, 8057.35, and 8201.66 respectively, whereas the fixed costs per adult milk animal were, NPRs 893.17, 1152, and 1032.95 respectively. The total costs per adult milk animal were NPRs 8111.3, 9209.42, and 9234.62 respectively for these kinds of farms. In mixed farming, there are problems withthe disposal of unproductive cows; this has in turn caused the total cost per animal to increase in such farms.

The average milk yield per lactation period per milk animal was 1600, 1525 and 1400litres for the large, medium and small scale of operation respectively. Based on this milk yield, the gross income of large, medium and small farmers was NPRs 15375.24, 14247.36 and 12938.54, respectively and on average the gross income was NPRs 12938.54. The net income from livestock production was NPRs 5322.3on the all-scale average basis.

The cost of production per litre milk per milk animal was NPRs 51.62, 56.6, and 67.83 for the large, medium and small scale farms respectively. The average cost per litre milk per milk animal was NPRs 58.7. The average price received by the farmer per litre of milk was NPRs

92.36, 89.65, and 88.38 for the large, medium and small-scale dairy farms respectively while the overall all-scale average price received per litre of milk was NPRs 90.13.

The results also showed that the highest price per litre of raw milk was prevalent in the cooperative-buyer channel (NPRs 83.01) followed by the producer-buyer channel (NPRs 82.8), producer-cooperative channel (NPRs 81.1) and cooperative-dairy channel (NRs 78.9). This showed that an appreciable amount of the margin was being dumped at the cooperatives or the chilling centres which if can be reduced to the basal needed level, can contribute a small increment in the price the farmers would receive for their milk.

The average cost of milk production has not changed significantly these years as compared to the previous year but there is some difference in the cost price for different scales of operation (large, medium and small) and farm types (cow only, buffalo only and mixed farms). The average margin per litre of milk was NPRs 40.74, 33, and 20.55 for the large, medium and small-scale dairy farms respectively and the all-scale average margin per litre of milk was NPRs 31.43.

6. RECOMMENDATION

According to the study's findings, inadequate support for better livestock production and a lack of a fixed and equitable price for milk are the main issues in the assessed locations. Therefore, in addition to the program's implementation, the following principal suggestions for enhancing and commercializing livestock husbandry are made to raise output and productivity in the areas surveyed. Based on the findings of the data collected by the field survey during this study, the team suggests some recommendations for minimizing the gap in dairy farming and improving animal productivity.

- The most important factor contributing to the cost was feed. Currently, the price of bagged commercial feed is increasing quickly so the farmers must be encouraged to forage-based farming. The forages to be used must have high nutritive value and palatability to the animals. Farming systems with cut and carry forages do not give desired productivity and production.
- The main cause of the high cost of milk production is the very low animal productivity and high cost of production. Thus creating a dairy animal resource centre or providing financial assistance to commercial farms to develop breeding stock with a proven pedigree history is necessary. The improved breeds undoubtedly give higher yields but they at the same time demand more inputs in terms of feeding, nutrition and management. Provided that the farmers can afford and supply the necessary inputs, the exotic cattle or buffalo breeds are beneficial in terms of milk yield.
- Large dairy farms have the lowest production costs, while small dairy farms have the greatest costs, by about 17%. Therefore, it is important to encourage large-scale dairy farming to lower the cost of milk production.
- Extension workers should be encouraged to make an effort and motivate farmers to acquire knowledge regarding feeding, breed purity, breeding, new technologies and good resource management to increase dairy producers' profits.
- The results showed that half of the respondents were cattle farmers whereas, among the remaining half, there was an equal number of buffalo and mixed farmers. In the Nepalese context, the cows are considered holy animals so are forbidden for slaughter by the law. However, there are many cases where the cows are suffering from zoonotic diseases such as brucellosis, tuberculosis, leptospirosis etc. In such cases, the positive animals are not only a threat to public health but also a primary cause of infertility which directly affects

production andproductivity. So it is recommended that some policy level revisions be made to address this issue in future.

- In line with the farmers'suggestions, it is recommended that there must be a system of two-times collection of milk. Milk collected during the evening times can be given a premium price to encourage milk collection.Good milk production practices, milk quality preservations and prevention of adulterations must be enforced and farmers are made aware of those issues.
- As a large portion of the margin from sales of milk is being dumped at the cooperative level, there must be some mechanism to provide subsidies based on production from the cooperative level in collaboration with the local government for the benefit of the farmers.
- As per the findings, the cost per litre of milk at the farmer’s level was approximately Rs. 58.7 which is higher than the last year’s price of NDDB, of Rs. 56.32. Thus the increased price of milk is NRs. 2.38 per litre.
- The average cost of production as stated in this report is desirable for the benefit of the farming community. The farmers should be paid with remunerative price for their milk. For this, a regular system of estimating and updating the farmers' cost of milk production should be established and milk price should be reviewed at regular intervals.

PICTORIAL GLIMPSES OF DATA COLLECTION


दुग्ध संकलन उत्पादन तथा विविधिकरण केन्द्र


बुद्धिराज एग्रो कृषि फार्म प्रा.लि.
Buddhiraj Agro Krishi Farm Pvt. Ltd.
POCO
SHOT ON POCO M2


POCO
SHOT ON POCO M2


POCO
SHOT ON POCO M2

ANNEX 1 Format used for data collection(milk producer)

!= s[ifssf] gfd

==========

====

7]ufgf M

k|b]z g+========== lhNnf========== d=g=kf=÷pk

d=g=kf=÷g=kf=÷uf=kf= ==== =====

j8f g+=

df]afO{n g+==========

lzIffM==========

@= kmfd{sf] k|sf/ M ufO{ dfq e};L dfq ufO{ e}+;L ldl>t

kmfd{sf] 7]ufgf ========== btf{

ldlt÷:yfg(दर्ताभएमा=)==========

#= ufO{e};Lsf] ;+Vof

kmfd{dfePsf ;j} Xfnb"wlbg]dfq

:yflgo pGgt hDdf :yflgo pGgt hDdf

E}f+;L

ufO{

$ कतिपुँजीलगानीगर्नुभयो ?

शेडनिर्माण

गाई/भैंसीखरिद

□□□□□ □ □□□□□

□□□□□□

कुनैअन्य

%तपाईंलेकुनैप्रोत्साहन/निशुल्कपैसाप्राप्तगर्नुभएकोछ?यदिहोभनेकतिरकुनस्रोतबाट?

कतिपैसा

कहिले

कुनस्रोतबाट

^. तपाईंलेत्योकोषकसरीप्रयोगगर्नुभयो?

गाईवस्तुगोठकोलागि

पशुखरिदकालागि

□□□□□ □ □□□□□

अन्य

&tkfO{sf] ufO{÷e}l;n] Ps lbgdfslt ln6/ b"w lbG5 <-cf};tdf_

-s_ ufO{M klxnf] @ dlxgf===== @ dlxgf b]vL ^ dlxgf ;Dd=======^ dlxgf b]vLdfly=======

v_ e}+;LM klxnf] @ dlxgf===== @ dlxgf b]vL ^ dlxgf ;Dd=======^ dlxgf b]vLdfly========

* kz' JofPkl5 aiflbgdfsltlbgb'x'g' x'G5 <

s_ ufO{df==========dlxgflbg v_ e}+;Ldf==========dlxgflbg

(cf}iftdf Ps k6s AofPsf] slt ;dodfcsf]{ k6s Aofp5 <

s_ ufO{========== v_ e};L==========

!) tkfO{n] pTkfbg u/]sf] b"w s] ug'{x'G5<

-s_ 3/dfvfg] -ln6/_ ===== -v_ j]Rg] -ln6/_ ==========-u_ cGo -v'nfpg'xf];_

!! s'gs'gdlxgfdf ;jeGbf jl9 tyfs'gs'gdlxgfdf ;j eGbfsdb"w j]Rg'x'G5 ?

jl9b"w j]lrg] dlxgfx?M

sdb"w j]lrg] dlxgfx?M

!@. उत्पादितदुधकहाँखपतहुन्छरकतिआम्दानीहुन्छ?

		बिक्री/vkt					
कुल उत्पादन	स्व-उपभोग	ljfnf	सहकारी संस्था	चिया/मिठाई	दुग्धजन्य पदार्थ जस्तै दही/घिउ बनाएर	cG	कुल
litre	Litre	Litre	Litre	Litre	Litre	Litre	Litre
प्रति लिटर							
प्राप्त रकम							
प्रति वर्ष अनुमानित बिक्री रकम							

!#. यदितपाईँऔपचारिकक्षेत्रमाबेच्नुहुन्छभने, केतिनीहरूलेतपाईँलाईगुणस्तरकोआधारमाभुक्तानीगर्छन्?

होवाहोइन

!$. यदिहोभनेगाईरभैंसीकोदूधमाप्रतिलिटरकतिपाउनुहुन्छ ?

गाईकोदूधभैंसीकोदूध

= !%= tkfO{ s;nfO{ b"w j]Rg ?rfpg'x'G5<lsg<

-s_ :yfgLolrofk;n÷xf]6n -v_ l5d]s

-u_ b'UwpTkfbs ;xsf/L ;+:yf -3_ 3/3/dfnluljs|Lug{} JolQm -ª_ cGo -v'nfpg'xf];_

!^. पशुपालनबाटआम्दानीकाअन्यस्रोतहरूकेकेहुन्?

स्रोतहरू	प्रति वर्ष अनुमानित मात्रा	प्रति वर्ष अनुमानित आम्दानी
गोबर /पिसाब lals		
lkf8f÷kf8L÷afF5f÷afF5Llals		
Dffp÷nlgf]kz'lals		
Yff/f kz'lals		
cG6		
sh		

!&= tkfO{n] 3f+; v]tLug'{ ePsf] 5 ls 5}g <

!* 3f+; v]tLug'{ ePsf] 5 eg], slthldgdf 3f+; v]tLug{' ePsf] 5 <

lf]qkmn -s7\7f_ Kf|d'v 3f+;x?

lxpb]

jif{]

jx'jif{]

!(3fF; v]ltsfnfuLhUuf ef8fdf lnPsf] 5 ls 5}g, lnPsf] eP,

s_ lf]qkmn ==========

v_ aflif{s ef8f==========

u_ s'gs'g 3f+; nufpg] ug'{ ePsf] 5

==========

===

@) jflif{s vr{ljj/0f

vr{ lzif{s kl/df0f ;/b/ k|ltOsfO{ dNo -?_ hDdfvr{ -?_ s}lkmot

! cfxf/f

!=! हरियोघाँसखरिद(आफ्नैस्रोतबाहेक)

!=@ rf]s/

!=# ds}

!=$ lkgf

!=% 9'6f]

!=^ bfgf

!=& k/fn (आफ्नैस्रोतबाहेक)

!=* 3f+;sf] ljp

hDdf

@ kfl/>lds

@=! jflx/L HofdL(वर्तमानदरमा) 3f+; v]tLdf ;d]t

@=@ 3/sf] sfdbf/ (Imputed value of family labour based of present rate)

hDdf

pkrf/ tyfcf}iflwvr{ (अनुमानितवार्षिकखर्च)

#=! cf}iflwldg/n le6fldg vr{

#=@ k|hgg

#=# K|ffs[ltsuef{wfg

#=$ AI

hDdf

$ शुल्कx?

$=! ljh'nL

$=@ kfgL

$=# hUuf ef8f lnhdflnPsf] ePdf

$=$ ljdfz'Ns

$=% cGoz'Ns

hDdf

% cGovr{x?

%=! C0fsf] jflif{s Jofh

%=@ l:y/ k+'hLx|f; s6\6L

hDdf

s"nhDdf

@!=cfDbfgL ;DaGwLlaa/0f -aflif{s_

qm; ljj/0f Afflif{s (Rs.)

! Total milk production in liter

@ b'wjf6 kfPsf] d"No

% अन्यस्रोतहरूबाट

hDdfcfDbfgL

@@= b'wsf] d'No s;/L lgwf{/0f x'g] ub{5<

-s_ ˆof6÷P;=Pg=Pkmb'j} -v_ ˆof6 dfq

-u_ cfk;L ;dhbf/L -3_ P;=Pg=Pkm÷s'n 7f]; kbfy{

@#= b"wsf] /sde'QmfgLk|ls|of

s_ b}lgs v_ ;fKtflxs

u_ cw{ dfl;s 3_ dfl;s ª_cGo

@$= ufO{ e}+;Lkfngdftkf0n] ef]Ug' k/]sfk|d'v ;d:ofx? -k|fyldss|dsf] cfwf/df_

s_==========

==========

v_==========

==========

u_==========

==========

3_==========

==========

@%= tkfO{sf] ljrf/dfvr{ s6fP/ nufgLsf] sltk|lt;tgfkmfhf]8L d'Nokfpg' ePsf] 5 h:tf]

nfU5 <==========

==========

==========

@^= tkfO{nfO{ s] s:tf] ;xof]u ePdfb'wpTkfbg a9\5 h:tf] nfu]sf]5 <

-s_ gofF ;+sng s]Gb÷;xsf/L vf]n]/ -v_ lr:ofg s]Gb| vf]n]/

-u_ kz'nfngtyfkz' :jf:Yodf ;]jfyk]/ -ª_ cGo -v'nfpg'xf];_

@&= बैंकबाटऋणलिनेप्रणालीलाईकसरीमूल्याङ्कनगर्नुहुन्छ?

धेरैसजिलो जटिल उच्चब्याजदर अधिकसमयखपत

@* b"wsf] jhf/ Joj:yfkgdfef]Ug k/]sfk|d'v ;d:ofx?M

s_==========

==========

v_==========

==========

u_==========

==========

3_==========

==========

@(= kz' kfngtyfb'UwAoa;fosf] lasf; / la:tf/sfnfuL s] ;'emfalbgrfxfg' x'G5<

s_==========

==========

v_==========

==========

u_==========

==========

tYof+s ;+snssf] gfd

b:tvt

tYof+spknAw u/fpg]sf] gfd

b:tvtM ldlt

ANNEX 2 Format used for data collection (KII &co-operatives format)

!= ;'rgfbftfsf] gfdM

$= 7]ufgfM

%= lzIffM

@= kb÷Joj;foM

#= sfof{no÷;+3÷;+:yf÷pBf]usf] gfdM

!= tkfO{sf] ufp+÷j8fdf b"wpTkfbs ;xsf/L ;+:yf 5g jf 5}gg< 5g eg] sltj6f 5g / ltlgx?sf] gfd s] s] x'g<

@= tkfO{sf] ufp÷j8fsf] s'g 7fp+df b'wpTkfbs ;xsf/L ;+:yf :yfkgfePdf al9 b'w ;+sngx'g ;S5 <

#= tkfO{nfO{ yfxfePsf] s'gufp+÷j8fdf al9 b'w ;+sngx'g ;S5 h:tf] nfU5 / To; :yfgjf6 df]6/ af6f] k'Ugslt ;do nfU5 <

+$= tkfO{sf] ufp+÷j8fdf ufO{ jf e}+;L s] sf] b'w al9 pTkfbg x'G5 / ;fy} s[ifsx?n] s'ghftsfkz' kfNg] ub{5g <

%= tkfO{sf] ufp+÷j8fdf kz'x?sf] d'Vocfxf/ s] xf] <

^= tkfO{sf] ufp+÷j8fdf s[ifsx?n] 3f+; v]tLug]{ u/]sf 5g ls 5}gg< 5}g geg] lsg / 5g eg] s:tf vfnsf -8fn] jfe'O{_ 3f+; v]ltub{5g <

&= tkfO{sf] ufp+dfkz'kfngjfb'UwJoj;fodf b]vf k/]sfd'Vod'Vo ;d:ofx? s] s] x'g<

*= tkfO{nfO{ yfxfeP;DdtkfO{sf] ufp+÷j8fdf kz'kfngjfb'wJoj;fo ;DjlGwsfdug]{ s'g} :yfgLo, k|b]zLo, /fli6o jfcGt/fli6o u}X ;/sf/L ;+:yfx? 5g < 5g eg] ltlgx?sf] gfd / ltlgx?n] s:tf k|j[ltsf ;]jfpknJw u/fpg] u/]sf 5g <

(= tkfO{n] g]kfnsf] b'Uw lf]qdf b]Vg' ePsfd'Vo ;d:ofx? s] xf]nf h:tf] nfU5 <

s_==========

v_==========

u_==========

3_==========

!)= tL ;d:ofx?nfO{ ;dfwfgug{ s] s:tf pkfox? ckgfpg' kg]{ x'G5 <

s_==========

v_==========

u_==========

3_==========

!!= tkfO{sf] lf]qdfsfdbf/x?n] b}lgsHofnfslt /x]sf]5 < -sfo{ slt 306fsf] x'G5 _

!@= tkfO{sf] lf]qdfb'wfn' ufO{ jf e}+;Lsf] d'Noslt /x]sf] 5 <

!#= tkfO{sf] lf]qdfb'UwpTkfbs s[ifsx?n] ef]Ug' k/]sfd'Vo ;d:ofx? s] s] x'g / tL ;d:ofx?nfO{ ;dfwfgug{ s] s:tf pkfox? ckgfpg' kg]{ x'G5 <

s_==========

v_==========

u_==========

3_==========

!$= tkfO{sf] lf]qdfb'UwpBf]un] ef]Ug' k/]sfd'Vo ;d:ofx? s] s] x'g / tL ;d:ofx?nfO{ ;dfwfgug{ s] s:tf pkfox? ckgfpg' kg]{ x'G5 < s_==========

v_==========

u_==========

ANNEX 3Summary offarmers' income and expenditure

Table A

	N		Mean	Std. Deviation	Maximum	Sum
	Valid	Missing				
Created by	530	0				
District	0	773				
Classification	530	243	1.2226	0.47574	3	648
Total animal	530	243	6.4849	7.72818	86	3437
Shed cost	530	243	200.5826	343.75557	4687.5	106308.78
Animal cost	530	243	446.1239	448.40376	5702.5	236445.68
Machineries	530	243	31.5101	235.31828	5000	16700.36
Land lease	530	243	128.5568	276.85623	1666.67	68135.08
Interest	530	243	16.1308	137.42021	2777.78	8549.31
Feed ready made	530	243	1853.38113	2477.094425	25000	982292.001
Dhuto-bran	530	243	725.72657	1083.900494	9000	384635.08
Bhus-chokar	530	243	1004.7409	1048.1409	7312.5	532512.67
Vitamin calcium	530	243	332.7589	770.19719	15000	176362.21
Medicine	530	243	347.81	494.82363	3684.21	184339.32
Vaccine	530	243	60.4649	189.7046	1500	32046.37
Breeding	530	243	146.3198	293.89428	3000	77549.49
Green grass	530	243	190.3436	786.90696	10000	100882.11
Straw	530	243	953.8517	1151.69496	8333.33	505541.39
Silage	530	243	7.448	56.31407	750	3947.45
Labor	530	243	159.2006	594.03731	7578.95	84376.3
Technical expenses	530	243	96.2806	243.87495	2500	51028.74
Electricity	530	243	120.9271	210.36972	1500	64091.34
Communication	530	243	19.9394	60.62998	625	10567.88
Fuel	530	243	27.105	165.53319	2500	14365.64
Seed	530	243	89.4416	289.74909	3500	47404.06
Others	530	243	94.8686	360.49843	4166.67	50280.36

Table B

		Per month milk per animal	Monthly income from milk per cattle	Other income per month per cattle	Classification
N	Valid	530	530	530	530
Mean		194.954	15593.4039	672.6268	1.2245
Median		179.1667	14580.2083	277.7778	1
Std. Deviation		91.82342	7507.64302	1106.45576	0.48079
Maximum		857.5	72887.5	13333.33	3
Sum		103325.62	8264504.06	356492.18	649

Table C

		Mode of price fixation	Classification
N	Valid	530	530
Mean		3.0245	1.2226
Median		3	1
Mode		3	1
Std. Deviation		0.77859	0.4797
Minimum		2	1
Maximum		4	3
Sum		1603	648

Table D

		Average milking cattle	Average milking buffalo	Parturition cattle	Parturition buffalo
N	Valid	389	257	393	267
Mean		300.3548	263.035	328.7303	364.8951
Median		305	270	330	400
Mode		305	270	365	365
Std. Deviation		60.04721	68.05285	82.93671	131.73582
Minimum		0	0	30	0
Maximum		654	540	730	730
Sum		116838	67600	129191	97427

Table E

		Average	Buyer	Cooperative	Cooperative buyer	Cooperative dairy	Classification	Margin
N	Valid	530	333	268	237	132	528	528
Mean		81.1132	85.0105	71.0896	86.5338	83.0265	1.2235	35.8865
Std. Deviation		14.49586	16.29142	14.30563	14.98781	18.46601	0.48041	41.19945
Maximum		140	140	135	130	135	3	102.17
Sum		42990	28308.5	19052	20508.5	10959.5	646	18948.05

Table F

		Fixed cost	Variable cost	Total cost	Classification	Province	Animal wise classification
N	Valid	530	530	530	530	530	530
Mean		808.2254	6198.4539	7006.6793	1.2245	3.2434	1.7245
Median		702.5	5000	5831.25	1	3	1
Mode		702.5	5000	2244.17a	1	3	1
Std. Deviation		726.23714	4180.13443	4506.94127	0.48079	1.00057	0.81779
Maximum		6952.5	36345	37214.17	3	7	3
Sum		428359.47	3285180.58	3713540.05	649	1719	914

a. Multiple modes exist. The smallest value is shown