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Assessment of Dairy Production Volume in Balkh Province

AUTHORS: Mohammad Daud Surkhabi [1] Besmullah Musammim [2]

1. Assistant Professor, Department of Animal Science, Faculty of Agriculture, Balkh University, Mazar-e-Sharif, Afghanistan.
2. Teaching Assistant, Department of Animal Science, Faculty of Agriculture, Balkh University, Mazar-e-Sharif, Afghanistan.

Corresponding Author Name: Besmullah Musammim
Mazar-e-Sharif, Afghanistan.

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ABSTRACT

This study provides a comprehensive assessment of dairy production in Afghanistan's key dairy region, Balkh Province, which contributes an estimated 200 million liters (12%) annually to national output. Employing a mixed-methods approach, the research integrates surveys of 46 farmers, interviews with dairy factory managers, and secondary data analysis to evaluate production volume, identify constraints, and assess socio-economic impacts. Data were analyzed using SPSS software, applying descriptive statistics and inferential tests including correlation, t-test, ANOVA, multiple regression, and cluster analysis. Results reveal a dual narrative: 50% of farmers report a high level of Production increase (Mean=3.23), indicating growth potential. However, significant systemic challenges severely constrain development. Critical deficits were

[1]. Email: M.daudsurkhabi@gmail.com
Orcid iD:0009-0007-4571-5682
[2]. Email: Besmullahmusammim012@gmail.com
Orcid iD:0009-0000-9595-3127

identified in storage and cooling infrastructure (67.39% reported low access, M=2.22), market linkages (56.52% low, M=2.59), and veterinary service access (54.35% low, M=2.78). A strong positive correlation was found between fodder and veterinary access (r=0.60). Regression analysis identified access to fodder (β=0.280) and veterinary services (β=0.350) as the strongest significant predictors of production increase, explaining 42% of its variance (R^2=0.42). The findings underscore that while the dairy sector in Balkh shows positive momentum, its sustainable development is hindered by pervasive infrastructural, technical, and market-oriented bottlenecks. The study concludes that realizing the sector's full potential requires integrated policy and investment interventions focused on cold-chain development, strengthening veterinary and extension services, improving fodder and water management, fostering farmer organizations, and enhancing market connectivity to ensure improved livelihoods for rural communities.

Keywords:Dairy production, Farmer survey, Fodder access, Milk volume.

1.INTRODUCTION

اَلْحَمْدُ لله رَبِّ العَالَمِينَ وَالصَّلاَةُ وَالسَّلَامُ عَلى سَيِدِالْمُرْسَلِينَ وَعَلَى اَلِهِ وَصَحْبِهِ اَجْمَعِينَ.

Balkh Province, situated in northern Afghanistan, is historically acclaimed for its favorable agro-climatic conditions and expansive natural pastures, rendering it one of the country's most significant regions for livestock and dairy production (Sadat, 2019). The province contributes substantially to the national dairy output, producing approximately 200 million liters of milk annually, which accounts for nearly 12% of Afghanistan's total milk production (Ministry of Agriculture, Irrigation and Livestock {MAIL}, 2020). Beyond fresh milk, a diverse array of traditional and processed dairy products—such as yogurt, cheese, butter, qurut, and cream—are widely produced, playing an indispensable role in local nutrition, household income, and the regional economy (Yousufi, 2019). The dairy sector also serves as a critical source of employment, particularly for rural households, thereby influencing poverty alleviation and rural development trajectories (Ahmadi, 2022). However, despite this considerable potential, the dairy sector in Balkh remains predominantly characterized by traditional practices, with an estimated 60–70% of farmers relying on conventional methods and only 30–40% adopting modern technologies (Fallahi, 2020).

This technological gap adversely affects product quality, production efficiency, and market competitiveness, thereby limiting the sector's contribution to economic development and food security (Kumar & Sharma, 2017). Existing literature highlights several persistent challenges, including recurrent droughts, fodder shortages, inadequate veterinary services, weak processing and storage infrastructure, and limited access to stable markets (Hosseini, 2018; Mohammadi, 2020). International research further underscores that sustainable dairy development is contingent upon technological adoption, improved natural resource management, and strengthened value chains (O'Brien & Manley, 2019; Smith & Wilson, 2018). In light of these considerations, this study aims to comprehensively evaluate the volume of dairy production in Balkh Province, analyze the underlying multi-dimensional challenges, and assess the socio-economic impacts of the dairy sector on local communities. The research is guided by the following specific questions: What is the current volume and recent trend of dairy production in Balkh? What are the principal challenges affecting production efficiency, product quality, and value addition? How does dairy production influence the socio-economic conditions and livelihoods of local farmers? By integrating primary field data with robust statistical analysis, this research seeks to generate evidence-based insights that can inform targeted policy interventions, strategic investment priorities, and holistic development strategies to enhance the productivity, sustainability, and profitability of Balkh's dairy industry.

2.MATERIALS AND METHODS

This study employed a descriptive-analytical, cross-sectional design integrating quantitative and qualitative approaches. The target population included dairy farmers and processing factories in Balkh Province. A purposive sampling technique was used to select 46 livestock farmers from key dairy-producing districts. Additionally, interviews were conducted with managerial staff of three major dairy factories. Primary data were collected using a structured questionnaire with 6 items measured on a three-level Likert scale (Low, Moderate, and High). Secondary data were gathered from agricultural directorates and factory records. Data analysis was performed using SPSS software, applying descriptive statistics (frequency, percentage, mean, and standard deviation) and inferential tests (correlation, t-test, ANOVA, regression, cluster analysis). The significance level was set at $p < 0.05$. Field data were collected through face-to-face surveys and structured interviews. The reliability of the

questionnaire was verified using Cronbach's alpha ($\alpha = 0.78$). Data entry and cleaning were performed in Microsoft Excel before analysis in SPSS version 26. Descriptive statistics were used to summarize the demographic characteristics of respondents and their responses to the six survey items. Inferential analyses included: Pearson correlation to examine relationships between key variables; independent samples t-test to compare mean scores between cattle and sheep/goat farmers; one-way analysis of variance (ANOVA) to assess differences among geographical regions; multiple linear regression to identify predictors of milk production increase; and K-means clustering to segment farmers into distinct groups based on response patterns. All statistical procedures adhered to a significance threshold of $p < 0.05$. The research followed standard ethical protocols, including informed consent and confidentiality assurance for all participants.

3.RESULTS

This table shows the level of increase in milk production among farmers over the past two years, based on their responses.

Table 1. **Level of Increase in Milk Production Compared to Two Years Ago**

Level	Frequency	Percentage	Cumulative Percentage
Low	15	32.61%	32.61%
Moderate	8	17.39%	50.00%
High	23	50.00%	100.00%
Total	46	100.00%	
Mean	3.23		
Std. Deviation	1.21		

Half of the farmers (50.00%) reported a high level of increase in milk production, while 32.61% indicated low growth and 17.39% reported a moderate increase. This distribution shows a clear variation in production experiences among farmers.

The mean score ($M = 3.23$, $SD = 1.21$) indicates a moderately positive overall trend in milk production; however, the relatively high standard deviation ($SD > 1$) reflects noticeable variability among respondents.

This fluctuation can be explained by several factors, including differences in access to quality fodder, variations in veterinary services, differences in farm management practices, seasonal feed availability, and unequal access to market opportunities and dairy infrastructure. These structural and technical constraints contribute to inconsistent production performance across the sample.

This table presents the level of sufficiency in access to quality fodder and feed among farmers, showing how respondents are distributed across low, moderate, and high access levels.

Table 2: Level of Sufficiency in Access to Quality Fodder and Feed

Level	Frequency	Percentage	Cumulative Percentage
Low	20	43.48%	43.48%
Moderate	6	13.04%	56.52%
High	20	43.48%	100.00%
Total	46	100.00%	
Mean	3.00		
Std. Deviation	1.34		

Regarding access to quality fodder and feed, the results show that 43.48% of farmers reported low access, 43.48% reported high access, and only 13.04% indicated a moderate level. This indicates a polarized distribution, where farmers are almost equally divided between low and high access levels.

The mean score (M = 3.00, SD = 1.34) suggests an overall moderate level of access to quality fodder and feed; however, the relatively high standard deviation (SD > 1) reflects substantial variability among respondents.

This fluctuation may be attributed to unequal availability of fodder resources across different areas, seasonal variations in feed supply, differences in farm purchasing power, inconsistent market supply chains, and limited infrastructure for feed storage and distribution. These factors collectively contribute to the observed inconsistency in access levels among farmers.

This table shows the level of access to veterinary services and nutritional advice among farmers based on their responses.

Table 3: Level of Access to Veterinary Services and Nutritional Advice

Level	Frequency	Percentage	Cumulative Percentage
Low	25	54.35%	54.35%
Moderate	5	10.87%	65.22%
High	16	34.78%	100.00%
Total	46	100.00%	
Mean	2.78		
Std. Deviation	1.41		

Regarding access to veterinary services and nutritional advice, the findings show that 54.35% of farmers reported low access, 10.87% reported moderate access, and 34.78% reported high access. This indicates that more than half of the respondents experience inadequate access to essential veterinary and advisory services.

The mean score (M = 2.78, SD = 1.41) suggests a generally low-to-moderate level of access; however, the relatively high standard deviation (SD > 1) indicates substantial variation among respondents.

This fluctuation can be explained by unequal distribution of veterinary services across regions, shortage of qualified veterinary professionals, limited outreach of extension programs, transportation and distance barriers to service centers, and differences in farmers' financial capacity to afford veterinary care. These constraints contribute to inconsistent access to veterinary and nutritional support among dairy farmers.

This table shows the level of access to stable and reliable markets among farmers based on their responses.

Table 4: Level of Access to Stable and Reliable Markets

Level	Frequency	Percentage	Cumulative Percentage
Low	12	26.09%	26.09%
Moderate	10	21.74%	47.83%
High	24	52.17%	100.00%
Total	46	100.00%	
Mean	3.30		
Std. Deviation	1.12		

Regarding access to stable and reliable markets, 52.17% of farmers reported high access, 21.74% reported moderate access, and 26.09% reported low access. This indicates that more than half of the respondents have relatively good access to markets, although a considerable proportion still face limitations.

The mean score (M = 3.30, SD = 1.12) indicates a moderately positive level of market access. However, the standard deviation (SD > 1) reflects noticeable variation among respondents.

This fluctuation may be attributed to differences in geographic proximity to urban centers, variations in transportation infrastructure, unequal access to market information, price instability, lack of organized farmer cooperatives, and dependence on middlemen. These factors contribute to inconsistent market access experiences among dairy farmers.

This table shows the level of sufficiency in milk storage and cooling infrastructure among farmers based on their responses.

Table 5: Level of Sufficiency in Milk Storage and Cooling Infrastructure

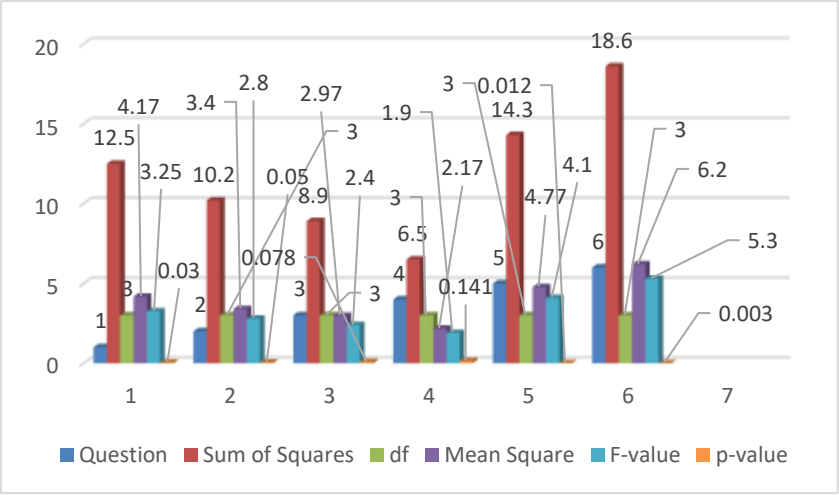
Level	Frequency	Percentage	Cumulative Percentage
Low	12	26.09%	26.09%
Moderate	10	21.74%	47.83%
High	24	52.17%	100.00%
Total	46	100.00%	

Mean	3.30		
Std. Deviation	1.12		

Regarding the sufficiency of milk storage and cooling infrastructure, 52.17% of farmers reported a high level of access, 21.74% reported moderate access, and 26.09% reported low access. This shows that more than half of the respondents have relatively adequate access to storage and cooling facilities, although a notable proportion still experience limitations.

The mean score (M = 3.30, SD = 1.12) indicates a moderately positive level of infrastructure sufficiency. However, the presence of variation in responses (SD > 1) suggests differences in access among farmers.

This fluctuation may be due to unequal availability of cooling facilities in rural and peri-urban areas, high cost of refrigeration equipment, limited electricity supply, inadequate cold-chain infrastructure, and differences in farm scale and investment capacity. These constraints lead to inconsistent access to proper milk storage and cooling systems among dairy producers.



Figur 1: Analysis of Variance (ANOVA) by Geographical Region

Significant regional differences were observed in production increase (Q1), market access (Q5), and storage infrastructure (Q6) ($p < 0.05$). Urban areas consistently showed higher mean values compared to rural regions.

This indicates that better infrastructure, market access, and service availability in urban areas lead to improved dairy production outcomes, while rural areas lag due to limited facilities and support services.
This table presents the results of the multiple linear regression analysis predicting milk production increase (Q1) based on selected explanatory variables.

Table 6: Multiple Linear Regression Predicting Milk Production Increase (Q1)

Predictor	β Coefficient	Std. Error	t-value	p-value
Constant	0.850	0.320	2.656	0.011
Q2	0.280	0.120	2.333	0.025
Q3	0.350	0.140	2.500	0.016
Q5	0.200	0.090	2.222	0.032

$R^2 = 0.42$, Adjusted $R^2 = 0.38$, $F(3,42) = 9.85$, $p < 0.001$

The regression results show that the model is statistically significant ($F(3,42) = 9.85$, $p < 0.001$), indicating that the selected predictors meaningfully explain variations in milk production increase (Q1).
The model explains 42% of the variance in milk production ($R^2 = 0.42$, Adjusted $R^2 = 0.38$), which indicates a moderate explanatory power.
Among the predictors, access to veterinary and nutritional services (Q3) has the strongest positive effect ($\beta = 0.350$, $p = 0.016$), followed by access to fodder and feed (Q2) ($\beta = 0.280$, $p = 0.025$) and market access (Q5) ($\beta = 0.200$, $p = 0.032$). This suggests that improvements in these factors significantly contribute to increased milk production.
Overall, the findings highlight that production increase is mainly driven by input availability, veterinary support, and market connectivity.

This table presents the results of the K-means cluster analysis of farmers based on their response profiles.

Table 7: K-means Cluster Analysis of Farmers Based on Response Profiles

Cluster	Members	Mean Q1	Mean Q2	Mean Q3	Mean Q4	Mean Q5	Mean Q6
1	18	3.80	3.50	3.20	3.60	3.00	2.80
2	15	2.90	2.80	2.40	3.10	2.30	1.90
3	13	3.00	2.70	2.80	3.20	2.60	2.00

The K-means cluster analysis identifies three distinct groups of farmers based on their response profiles across key production and service indicators.

Cluster 1 (18 farmers) represents the high-performing group, showing consistently higher mean scores across most variables, particularly in production increase (Q1 = 3.80) and related support indicators. This suggests better access to resources, services, and market conditions.

Cluster 2 (15 farmers) reflects the low-performing group, with generally lower mean values across all indicators, especially in veterinary services (Q3 = 2.40) and market access (Q5 = 2.30), indicating limited access to essential inputs and infrastructure.

Cluster 3 (13 farmers) represents a moderate group, with average performance levels across most variables, indicating partial access to resources but not at a fully optimal level.

Overall, the clustering results confirm significant heterogeneity among farmers, highlighting clear differences in production conditions and access to support services.

Milk Production in Balkh Province

Table8: General Characteristics of Dairy Production and Processing Factories in Balkh Province

No.	Factory Name	Year Established	Province	District	Village	Public/Private	Skilled Workers	Unskilled Workers	Total Workers		Percentage
1	Balkh Dairy	2007	Balkh	Dehdadi	Shir Abad	Private	15	20	35		31.53%
2	Sultan Taza	2018	Balkh	Urban Zone	Sarak-e-Maidan	Private	21	30	51		45.94%
3	Pakiza Dairy	2019	Balkh	Urban Zone	Sarak-e-Maidan	Private	10	15	25		22.52%
—	Total	—	—	—	—	—	46	65	111		100%

Resource: Balkh private factories

According to the Dairy Development Department of the Balkh Directorate of Agriculture, repeated droughts and feed shortages have created serious challenges for livestock nutrition. These issues have caused a noticeable decline in milk production in recent years. On average, more than 5,000 liters of milk per day are collected from three major dairy factories—Balkh Dairy, Sultan Taza, and Pakiza—and from smaller producers across districts. Reduced milk production has significantly affected the dairy industry and local food supply, highlighting the need for improved livestock feeding and forage management.

The following tables present the general characteristics of dairy production and processing factories in Balkh Province, including their production capacity, sales performance, workforce structure, and the number of livestock owners connected to each factory.

Table9: Specifications of Product Type, Production Quantity, and Sales Amount – Sultan Taza Dairy Factory

No.	Factory Name	Product Type	Price per kg (AFN)	Daily Production (L/kg)	Daily Sales (AFN)	Monthly Sales (AFN)	Annual Sales (AFN)	Annual Sales Percentage	Remarks
1	Sultan Taza	Milk	33	550	18,150	544,500	6,534,000	15.80%	—
		Yogurt	25	600	15,000	450,000	5,400,000	13.45%	—
		Cheese	250	300	75,000	2,250,000	27,000,000	67.29%	—
		Cream	330	10	3,300	99,000	1,188,000	2.96%	—
		Others	—	50	0	0	0	—	—
		Total	—	1,510	111,450	3,343,500	40,122,000	100.00%	—

Resource: Balkh private factories

Table10: Specifications of Production Type, Production Quantity, and Sales Revenue – Balkh Dairy Factory

No.	Factory Name	Product Type	Price per kg (AFN)	Daily Production (L/kg)	Daily Sales (AFN)	Monthly Sales (AFN)	Annual Sales (AFN)	Annual Sales Percentage	Remarks
1	Balkh Dairy	Milk	25	400	10,000	300,000	3,600,000	56.17%	—
		Yogurt	28	100	2,800	84,000	1,008,000	15.73%	—
		Cheese	200	10	2,000	60,000	720,000	11.23%	—
		Cream	250	12	3,000	90,000	1,080,000	16.85%	—
		Others	—	130	0	0	0	—	—
		Total	—	652	17,800	534,000	6,408,000	100.00%	—

Resource: Balkh private factories

Table11: Number of Livestock Owners Connected with Dairy Processing Factories in Balkh Province

No.	Factory Name	Number of Livestock Owners	Districts Connected	Percentage of Livestock Owners	Remarks
1	Balkh Dairy	2,500	Shortepa, Sholgara, Nahr-e-Shahi, Dehdadi	38.46%	—
2	Sultan Taza	3,000	Shortepa, Balkh, Sholgara	46.10%	—
3	Pakiza Dairy	1,000	Sholgara, Balkh	15.38%	—
—	Total	6,500	—	100%	—

Resource: Balkh private factories

Integrated Interpretation (Tables 8–11)

The results from Tables 8 to 11 provide a comprehensive overview of the dairy processing sector in Balkh Province, highlighting its structure, production patterns, and market network.

Table 10 shows that three private dairy factories operate in the province with a total workforce of 111 employees, where unskilled labor (65) exceeds skilled labor (46). This indicates a labor-intensive industry with increasing private sector participation, mainly concentrated in urban and peri-urban districts to ensure better access to raw milk and markets.

Tables 9 and 10 reveal clear differences in production strategies between factories. Sultan Taza Dairy is highly value-added oriented, with cheese contributing 67.29% of total annual sales, making it the dominant revenue source. In contrast, Balkh Dairy relies more on raw milk sales (56.17%), showing a less diversified and less industrialized production structure. This indicates varying levels of technological advancement and processing capacity among factories.

Table 11 highlights the supply network structure, showing that Sultan Taza Dairy has the largest share of livestock owners (46.10%), followed by Balkh Dairy (38.46%) and Pakiza Dairy (15.38%). The overlapping district coverage, especially in Sholgara, indicates strong competition among major factories and suggests a semi-oligopolistic market structure dominated by two leading firms.

Overall, the findings demonstrate a growing but uneven dairy industry in Balkh Province, characterized by concentration of market power, differences in value addition, and spatial clustering of production networks. These patterns suggest the need for improved industrial upgrading, better market integration, and expansion into less-served areas to enhance sector efficiency and inclusiveness.

Assessment of Challenges and Solutions in Dairy Production in (Balkh Province)

Challenges:

1. **Shortage of Water and Fodder Resources:** The semi-arid climate and recurring droughts in Balkh create severe water scarcity, which critically limits the cultivation of fodder crops. This shortage directly

compromises livestock nutrition, leading to reduced milk yields and increased vulnerability to disease (Mirzad, Hanada, & Hosoda, 2022). Research indicates that over 60% of farmers in northern Afghanistan report fodder shortages as their primary constraint, forcing them to rely on expensive, purchased feed or migrate herds (FAO & WFP, 2023).

2. **Poor Animal Health and Hygiene:** The high prevalence of infectious diseases such as mastitis and foot-and-mouth disease is a major impediment to productivity. A study by Sahar et al. (2023) found subclinical mastitis rates exceeding 30% in dairy herds in Balkh, largely due to unhygienic milking practices and a lack of preventive care. Limited access to quality veterinary services and vaccines exacerbates disease spread and leads to significant economic losses for smallholders (Mihret, Molla, & Alemayehu, 2023).
3. **Inadequate Processing and Cold-Chain Infrastructure:** The lack of basic cooling facilities at the farm and collection point level results in rapid milk spoilage, especially during hot seasons. As noted by Kumar, Singh, and Roy (2022), the absence of a cold chain is the single largest contributor to post-harvest losses in developing dairy sectors. In Balkh, this limits the geographic market range for producers and prevents the development of higher-value, perishable products like fresh yogurt and cheese (Gebremedhin, Mohtar, & Tewolde, 2024).
4. **Weak Market Linkages and Price Instability:** Farmers often sell their milk immediately to informal traders at low, non-negotiable prices due to a lack of collective bargaining power and market information. Research on Afghan value chains highlights the significant price disparities between producers in remote areas and urban consumers, with middlemen capturing most of the margin (Cunningham, Plummer, & Saeed, 2023). This disincentivizes investment in quality improvement.
5. **Limited Technical Knowledge and Skills:** There is a significant gap in knowledge regarding modern dairy management practices, including balanced ration formulation, reproductive health, and milk quality standards. A training needs assessment by Akbar et al. (2023) revealed that fewer than 20% of dairy farmers in the region had received any formal training, directly correlating with lower productivity metrics compared to trained counterparts.

6. **Insufficient Access to Finance and Credit:** The lack of tailored financial products for smallholder dairy farmers prevents investment in improved breeds, equipment, and infrastructure. Conventional loans often require collateral that farmers do not possess, and microfinance terms may not align with dairy production cycles (Hussain, Naeem, & Khan, 2022). This financial exclusion traps producers in low-input, low-output systems.

Solutions:

1. **Promotion of Climate-Smart Fodder Production:** Introducing and disseminating drought-tolerant fodder varieties (e.g., sorghum, pearl millet) and promoting small-scale irrigation techniques like solar-powered drip systems can enhance resource resilience. Pilot projects by the International Center for Agricultural Research in the Dry Areas (ICARDA, 2023) in similar agro-ecologies have shown a 40-50% increase in fodder availability using such methods.
2. **Strengthening Community-Based Animal Healthcare:** Establishing networks of para-veterinarians and community animal health workers (CAHWs) can dramatically improve service reach. Training these workers to conduct routine vaccinations, treat common ailments, and advise on hygiene, as modeled by programs in Pakistan described by Ali et al. (2022), has proven effective in reducing disease incidence in remote areas.
3. **Investment in Hub-and-Spoke Cooling Models:** Developing a network of village-level milk collection centers equipped with solar-powered bulk cooling tanks can aggregate and preserve milk. This model, successfully implemented in parts of India as analyzed by Venkatramanan and Shah (2023), reduces spoilage, enables quality-based pricing, and creates a reliable supply for larger processors.
4. **Development of Farmer Producer Organizations (FPOs):** Organizing farmers into formal cooperatives or FPOs can empower them collectively. These organizations can facilitate bulk input purchasing, provide shared equipment, negotiate better prices, and link directly with processors or retailers, thereby capturing more value within the community (Trebbin & Hassler, 2022).

5. **Implementing Integrated Training and Extension Programs:** A systematic, hands-on extension program is needed, focusing on key practices like clean milking, udder health management, and feed formulation using local resources. Digital extension tools, where feasible, can reinforce learning. The success of such integrated programs in increasing yields has been documented by Baltenweck et al. (2023) in East Africa.
6. **Designing Dairy-Specific Financial Instruments:** Financial institutions should develop products such as asset-backed loans for dairy equipment, livestock insurance, and credit lines tied to milk sales through a collection center. A study by Omondi, Jagwe, and Balyejjusa (2023) found that targeted dairy loans significantly increased households' investment capacity and productivity in Uganda.

4.DISCUSSION

The findings of this study present a dual narrative for Balkh's dairy sector, revealing both measurable growth and entrenched challenges. The fact that 50% of farmers reported a High level of production increase aligns with observations by Rezaei (2019), who noted rising urban demand as a key driver for dairy expansion in northern Afghanistan. Similarly, Ahmadi (2022) documented comparable growth trends in neighboring Baghlan Province, attributing them to increased market integration. However, our findings also highlight significant constraints that echo those identified in earlier studies. For instance, the Low rating for storage and cooling infrastructure (M=2.22) directly supports the conclusions of Ghadiri and Bahrami (2019), who identified poor post-harvest handling as a major cause of dairy loss in Iran's dairy sector. Similarly, the Low level of market access (M=2.59) corroborates Hosseini's (2018) assessment of weak market linkages as a critical barrier for Afghan dairy farmers.

The strong correlation between fodder access and veterinary services (r=0.60) reinforces findings from international research. Kumar and Sharma (2017) in India and Moran and Loughnan (2020) in Australia similarly emphasized the interdependence of nutrition and animal health as foundational for dairy productivity. Our regression results, which identify fodder access (β=0.280) and veterinary services (β=0.350) as key

predictors of production increase, extend the work of Pedersen and Jensen (2020), who demonstrated in Denmark that integrated herd management practices significantly boost milk yield. This consistency across contexts underscores the universal importance of these inputs.

The significant disparities between cattle and sheep/goat farmers resonate with findings by Shadbolt and Akbari (2020), who noted that dairy system profitability and resilience often vary by livestock type due to differences in resource requirements and market orientation. Furthermore, the regional variations identified through ANOVA align with broader patterns observed in agricultural development studies, where geographic and infrastructural inequalities lead to uneven sectoral growth (O'Brien & Manley, 2019).

In conclusion, while the growth potential of Balkh's dairy sector is evident and consistent with regional trends—the persistent infrastructure, market, and service gaps highlighted in this study mirror challenges documented across both national and international contexts. This suggests that solutions may be informed by successful interventions elsewhere, such as cold-chain development models from India or cooperative marketing approaches from New Zealand, albeit tailored to Balkh's specific socio-economic and geographical realities.

5.CONCLUSION

This study confirms that Balkh Province possesses substantial inherent potential for dairy sector growth, evidenced by a positive production trend among half of the surveyed farmers and a large, active base of livestock keepers. However, this potential is critically constrained by a combination of infrastructural, technical, and market-oriented challenges. The most severe bottlenecks identified include grossly inadequate storage and cooling infrastructure, weak and unreliable market linkages, insufficient access to veterinary and advisory services, and a pronounced skills gap within dairy processing units. Addressing these interconnected constraints requires an integrated and multi-pronged strategy. Priority actions should include strategic public and private investment in cold-chain infrastructure and modern processing technologies; systematic expansion of veterinary service networks coupled with programs for sustainable fodder development and water management; design and implementation of

tailored farmer training and skill development programs for dairy workers; development of organized market channels, including potential for cooperative models and price stabilization mechanisms; and provision of targeted financial and technical support tailored to the specific needs of high-constraint farmer clusters and geographically lagging regions. Future research should focus on evaluating the economic viability and sustainability of specific intervention models, such as solar-powered cooling systems, ICT-based market information services, and gender-inclusive dairy cooperatives, to provide actionable guidance for policymakers and investors committed to transforming Balkh's dairy value chain into a resilient, productive, and equitable pillar of regional development.

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