ISBN 978-1-960740-00-7

DAIRY SCIENCES - CURRENT TECHNOLOGICAL TRENDS AND FUTURE PERSPECTIVES

Editors

Muhammad Nadeem & Muhammad Haseeb Ahmad

Review Based Book Chapter

Sustaining the Dairy Sector in Pakistan: Challenges and Strategies for Growth

February 14, 2024

doi: 10.5281/zenodo.10580675

Scientific Knowledge Publisher (SciKnowPub), USA

info@sciknowpub.com

REVIEW BASED BOOK CHAPTER

Sustaining the Dairy Sector in Pakistan: Challenges and Strategies for Growth

Farzana Siddique[1], Zoha Ali[1], Kinza Mubeen[1], Muhammad Arshad[2], Afsheen Ghazala[1]

[1]*Institute of Food Science and Nutrition, University of Sargodha, Sargodha-40100, Pakistan*
[2]*Department of Zoology, University of Sargodha, Sargodha-40100, Pakistan*

For Correspondence
farzana.siddique@uos.edu.pk

Abstract

This chapter critically evaluates the significant challenges encountered by the dairy industry in Pakistan between 2013 and 2023. Despite being a leading dairy powerhouse, boasting expansion and improvements over the last decade, the industry has faced numerous substantial obstacles that have hindered its progress. This chapter provides an in-depth examination of these constraints and their subsequent impact on the industry's performance, profitability, and competitive environment. It anticipates and addresses potential future challenges, such as antibiotics and Aflatoxins, considerations for ß-casein protein, introducing dairy animals with high genetic potential, and drivers of operating costs. These findings offer a rich reservoir of knowledge for policymakers, industry leaders, and researchers in this sector. The chapter also proposes potential approaches to these challenges to improve the industry's outlook.

Keywords
Dairy Industry, Milk Production, Milk Consumption, Future Challenges, Supply Chain, Livestock Breeds, Dairy Issues

1. Introduction

Pakistan's agricultural economy thrives on the critical contribution of the dairy sector, which has noticeably catalyzed substantial growth in agricultural output. Firmly embedded as a cornerstone in the economic structure, this industry offers financial assistance, vital income streams for rural residents, and ample job opportunities [1]. Striking figures from the Pakistan Bureau of Statistics indicate that the livestock sector, including dairy, will constitute roughly 60% of total agricultural production by the year 2020 [2]. Worldwide, Pakistan holds the fourth position in dairy production, as evidenced by its significant consumption of fresh milk, comprising 97% of total intake, while the

remaining 3% is pasteurized milk [3]. Recent government intervention underscores the significance of dairy farming, supporting small farmers' livelihoods [4]. Among over 8 million rural households engaged in livestock, small-scale farmers grapple with challenges linked to shifting climate [5]. Addressing the need for increased animal protein, dairy development projects target enhanced productivity through crossbreeding with high-yielding varieties [6].

This chapter is dedicated to identifying the challenges encountered by the dairy industry in Pakistan from 2013 to 2023 and proposing potential solutions to these issues. The objective is to highlight the primary restrictions that have hampered the country's dairy industry's growth and development over this period. This chapter will also provide an assessment of the current situation of the dairy business and highlight potential possibilities for future expansion.

2. General Characteristics of Dairy Farming

In the context of Pakistan, the private sector predominantly participates in urban and rural dairy farming across varying scales. However, the prevailing perception of the sector portrays it as fragmented and oriented towards subsistence. Except for a handful of peri-urban establishments, the bulk of dairy production occurs within integrated crop-livestock systems. Existing research primarily classifies farms based on geographical location and herd magnitude, delineating four key principal milk production systems: smallholder subsistence, smallholder market-oriented, rural commercial, and peri-urban [7]. They are described in the sections that follow:

2.1. Smallholder subsistence system

Rural locales harboring micro-farmers devoid of significant milk market access contribute milk at an economically frugal rate tailored to familial requisites. An archetypical subsistence entity encompasses a trinity of buffalo specimens. Eliciting an average bovine milk yield of 3 liters daily, this modality routinely hinges on non-monetary assets, notably kin-owned land, and labor, as pivotal constituents underpinning dairy production endeavors within these households. This category encapsulates 70% of smallholder milk producers [8].

2.2. Smallholder market-oriented system

In this context, farmers possess direct access to a dairy market, fostering a proclivity for heightened production beyond familial needs. The elemental structure of this production scheme entails a family-owned collective of five buffaloes. This assembly comprises a male calf, one or potentially two female followers, and three mature female specimens [9]. Milk is marketed through numerous routes, through direct sales to nearby local shops, and transactions with intermediaries or agents employed by milk-handling businesses [10].

2.3. Rural commercial system

Milk is brought twice daily to the market. The principal expenditures within this framework involve hired labor, animal housing, veterinary care, animal feed, water supply, electricity expenditures, and the cost of milk transportation. Milk is supplied directly to municipal retailers or through annual contracts with intermediaries. Recent breakthroughs within the dairy sector have spurred sure forward-thinking farmers to amplify their investments in milk production. However, these progressive initiatives represent a mere fraction, touching only 1% of United States dairy farms [11]. On average, milk yield per cow is 10 liters each day.

2.4. Peri-urban system

Peri-urban production unfolds within expansive marketable enterprises on the fringes of key urban centers. These establishments maintain conservation herds spanning a range of ten to 200 head, typifying an average of 50 animals. Predominantly, these herds comprise 90 percent buffalo and 10 percent cows [12]. Milk transportation to the market transpires twice daily. The milk supply mechanism encompasses two avenues: direct provision to local municipal retailers or execution via yearly contractual agreements with intermediaries [13]. A visual representation of milk production across diverse manufacturing systems is illustrated in Figure 1.

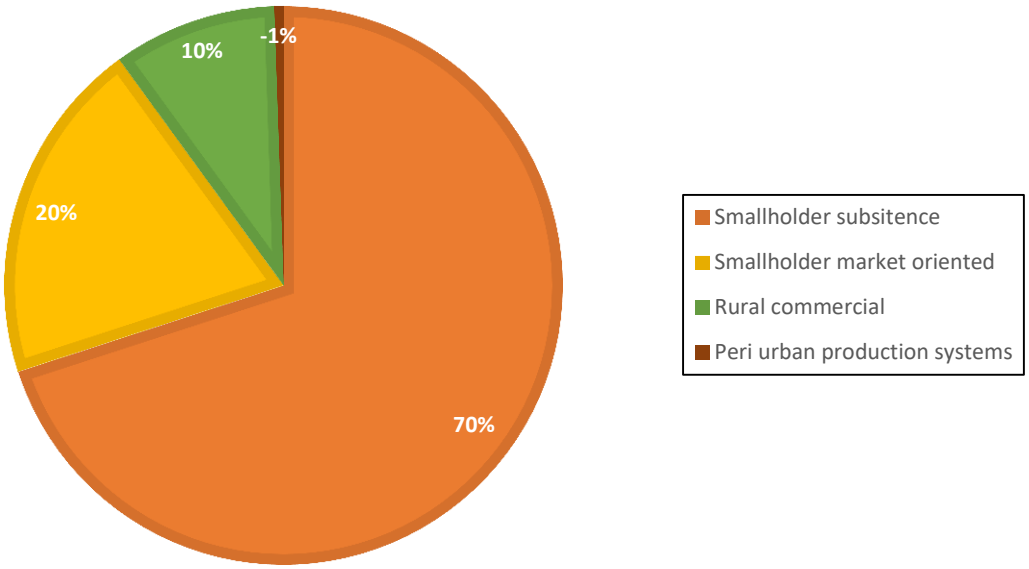

Figure 1: Milk production from various manufacturing systems

3. Trends in Milk Production

The provided Table 1 offers insights into the milk output across various animal species, represented in thousand tons, spanning the years from 2013-14 to 2021-22. The total milk production increased from 50,990 to 65,745 thousand metric tonnes during this time. More cow and buffalo milk contributed to the majority of this increase. Goat and sheep milk remained the same, but camel milk slightly increased, as shown in Table 1, while Figure 2 graphically illustrates the anticipated milk output from 2013-2023.

4. Trends in Milk Consumption

Table 2 delineates human milk consumption in thousand tons and the corresponding milk consumption of various livestock species for each year from 2013-22. Human milk consumption witnessed a gradual upsurge, ascending from 41,133 thousand tons in 2013–14 to 52,996 thousand tons. The graphic depiction of estimated human milk consumption is presented in Figure 3.

Table 1: The expected milk production for the years 2013-22 in 000 tonnes

Species	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Cow	18,027	18706	19412	20143	20,903	21,691	22,508	23,357	24,238
Buffalo	31,252	32,180	33137	34122	35,136	36,180	37,256	38,363	39,503
Sheep	38	38	39	39	40	40	41	41	42
Goat	822	945	867	891	915	940	965	991	1018
Camel	851	862	873	885	896	908	920	932	944
Milk Gross Production	50,990	52,632	54,328	56,080	57,890	59,759	61,690	63,684	65,745

Source: An Economic Survey of Pakistan (2013-2022)

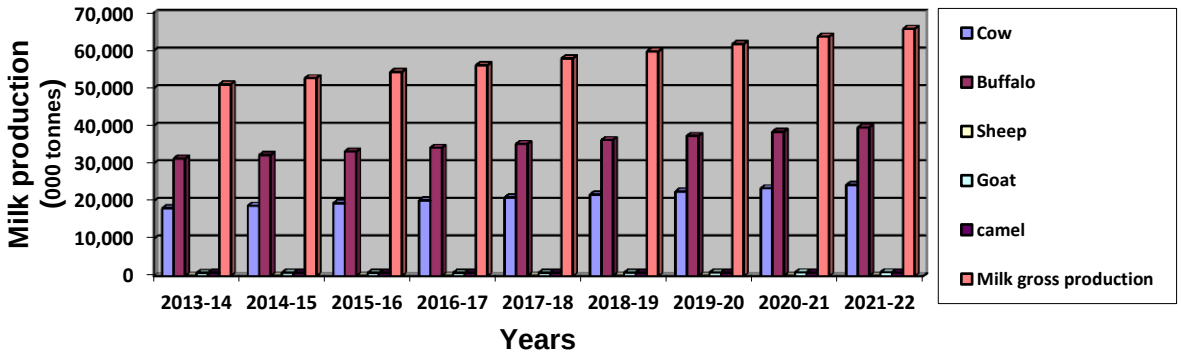

Figure 2: A graphical illustration of projected milk output for the years 2013-22
Source: Pakistan Economic Survey

Table 2: The estimated human milk consumption from 2013 to 22 000 tonnes

Species	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Cow	14,421	14,956	15,529	16,115	16,722	17,353	18,007	18,686	19,390
Buffalo	25,001	25,744	26,510	27,298	28,109	28,944	29,805	30,691	31,603
Sheep	38	38	39	39	40	40	41	41	42
Goat	822	845	867	891	915	940	965	991	1018
Camel	851	862	873	885	896	908	920	932	944
Milk (Human Consumption)	41,133	42,454	43,818	45,227	46,682	48,185	39,737	51,340	52,996

Source: An Economic Survey of Pakistan (2013-2022)

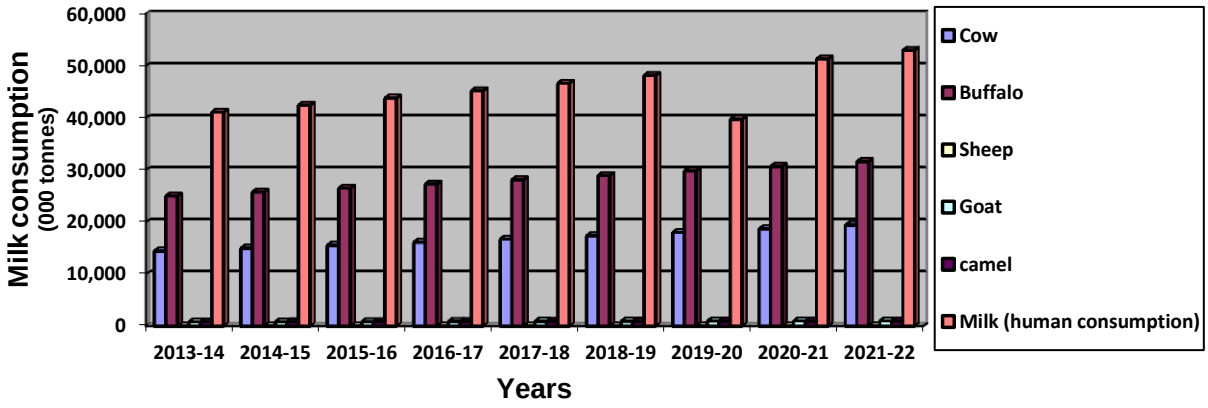

Figure 3: A graphical illustration of estimated human milk consumption in the years 2013-22
Source: Pakistan Economic Survey

5. Livestock Population

Table 3 demonstrates an increase in cattle and buffalo farming, with respective shares rising to 53.4% and 43.7%, respectively. Goat farming increased dramatically to 82.5%, while sheep farming stayed steady at 30%. Figure 4 provides additional information on the increased number of cattle between 2013 and 2022.

Table 3: Cattle population (2013-2022) in percentage

Species	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Cattle	39.7	41.2	42.8	44.4	46.1	47.8	49.6	51.5	53.4
Buffalo	34.6	35.6	36.6	37.7	38.8	40.0	41.2	42.4	43.7
Sheep	29.1	29.4	29.8	30.1	30.5	30.9	31.2	31.6	31.9
Goat	66.6	68.4	70.3	72.2	74.1	76.1	78.2	80.3	82.5

Source: Pakistan Economic Survey (2013-22). This statistic is based on the inter-census rate of growth of livestock censuses conducted in 1996 and 2006.

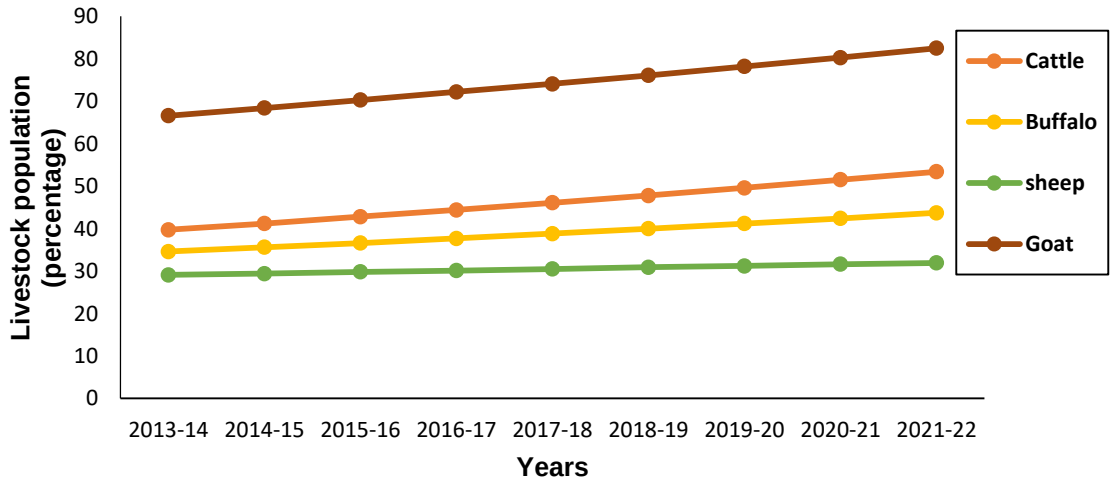

Figure 4: A graphical representation of the Livestock population from 2013 to 2022

6. Issues Regarding the Dairy Industry

Pakistan's dairy sector ranks fifth globally, generating a production volume of $26 billion across urban and rural areas [14]. Despite a growing population and rising domestic consumption, the milk output exceeds the population's demands. The daily shortage of milk in Karachi alone is approximately four million liters, and the demand and supply gap is projected to reach 3.6 billion liters by 2015 [15]. The rationale behind this phenomenon is rooted in the fact that the yearly rise in milk production cannot match the concurrent 3% expansion in both per capita consumption and human population. While milk production has indeed seen an uptick over time, this growth is attributed not to enhanced productivity per individual animal but rather to a surge in the overall count of animals [16]. The dairy industry's low productivity can be attributed to several factors, such as inadequate genetic resources, delayed puberty, suboptimal feed availability, high incidence of diseases, absence of a well-structured marketing system for livestock, inadequate research facilities, shortage of veterinarians, and insufficient rural infrastructure [17]. The COVID-19 pandemic brought significant distraction to the global dairy economy. The milk demand experienced daily escalation; however, the supply contracted amid the pandemic. Consequently, a substantial disparity emerged between market demand and the potential supply chain [18]. The devastating figure of 57.3 billion liters of unsold milk alongside other dairy products due to COVID-19 highlights the need for an irrepressible food system and sustenance for farmers [19].

Pakistan ranks third globally in animal herd size, with roughly 63 million animals, per the 2009 Economic Survey of Pakistan [20]. However, small-holding dairy farmers face a significant challenge in milk productivity due to the need for genetic resources and other factors [21]. During the lactation cycle, the milk productivity of cattle and buffalos does not exceed 4-5 liters per day. In Pakistan, it takes about 8 milk-producing animals to equal the productivity of a single animal in the developed world [22]. Additionally, milk production is affected by seasonal changes, with a 55% drop in peak production during May and June, which coincides with a 60% increase in demand compared to December, when there is abundant supply [23]. Milk's quality and shelf life are also compromised during May, yet the prices increase due to market shortages [24].

Previously, animals were smuggled or imported from Afghanistan, but the livestock sector has been adversely affected by the war in Afghanistan since 9/11[25]. Pakistan increased its livestock exports to Afghanistan, Iran, and Gulf states as a result of mad cow disease in Europe, which created a demand for livestock in these regions. This led to a shortage of raw materials for leather industries, prompting the government to take corrective measures to ensure a steady supply. Despite the potential for growth in Pakistan's Dairy Sector, various loopholes hinder its development. There needs to be more cooperation, and a clear plan for dairy progress among governing bodies and supporting organizations is a contributing factor [26]. Adulteration and unhygienic practices during milk handling by intermediaries, who add ice and sometimes vegetable oil to the milk, pose health risks [27]. Although government regulation could address this issue, the lack of developed milk collection systems means that only a tiny portion of the milk is appropriately collected and handled [28].

6.1. Insufficient supply of nutrients

Enhancing the quality and quantity of feed can increase livestock productivity by up to 50% [29]. In Pakistan, crops, bushes, grasses, and waste meet dairy animals' nutritional needs [30]. Foraging provides up to 95% of the nutrients [31], but the lack of available feed and fodder limits milk production [32]. The shrinking area for fodder production and its short supply time worsen the situation [33]. Pakistan necessitates around 10.9 of crude protein (CP) and 90.36 million tons of total digestible nutrients (TDN) per year for its 121.1 million livestock. According to AKRAM and FIRINCIOLU (2019), Livestock currently receives 51% of their nutritional needs from green fodder, 38% from crop wastes,3% from grazing vacant land, 6 % from post-harvest grazing, and 2% from cereal by-products, and oilcake and meals, respectively. The nutrient gaping hole could be reduced with better agricultural practices and inputs.

6.2. Decline of range lands

Ranges are vital in resource management, with rangelands encompassing 63% of Pakistan's total land area [34]. Rangelands are projected to provide 38% of Pakistan's livestock feed, establishing the second most significant contribution, surpassed only by

remnants of fodder-crop cultivation (51%) [35]. The poor pasture quality of these rangelands is one of the focal reasons for the decreased productivity of our animals [36]. Rangelands are undergoing degradation through overgrazing, nutrient deficiencies, rapid deforestation, and the uprooting of their range of vegetation. The deterioration of rangelands is evident, while effective strategies to sustain their productivity are still lacking. Historically, minimal research endeavors have been dedicated to enhancing rangeland conditions.

6.3. Animal health issues

In 2019–20, Pakistan had about 201 million livestock, primarily buffaloes and cows, at risk of diseases due to factors like contaminated water, improper feeding, and harsh weather [37]. Farmers do not fully utilize their benefits despite the availability of veterinary clinics, with only about 10% of the cattle herd receiving annual vaccinations [38]. A continuous vaccination program for diseases like foot and mouth is lacking, significantly impacting production. Major endemic livestock diseases in Pakistan include Foot and Mouth Disease (FMD), Hemorrhagic Septicemia (HS), Black Quarter (BQ), and diseases like sheep pox, anthrax, and enterotoxemia in sheep and goats [39].

6.4. Marketing-related concerns

Milk marketing in Pakistan faces challenges like inadequate infrastructure, leading to spoilage and waste. Lack of refrigeration, transport, and processing facilities causes up to 20% of milk wastage [40, 41]. The system disadvantages small producers, with middlemen monopolizing the market [42]. The scarcity of collection centers and limited testing facilities result in the sale of substandard milk [43, 44]. Seasonal production fluctuations, storage issues, and adulteration practices exacerbate the problem [45].

6.5. A lack of value-added resources

Within this nation, a scarcity of value-added infrastructure is glaringly evident [46]. The importance of this perilous issue must be given top precedence if dairying is to become a more lucrative sector. Value-added animal goods and byproducts are in high

demand and sold at high rates in the global markets. Flavors and colors are designed to influence consumers' preferences while considering their taste profile eating habits. Value-added milk from goats and camels is in high demand worldwide, and this industry has the potential to increase profitability.

6.6. Issue of peri-urban dairy colonies

Peri-urban dairy colonies in Pakistan face numerous challenges that impact the dairy industry and the local communities. Rapid urbanization leads to competition for agricultural land, reducing grazing areas for dairy farming [47]. Environmental pollution from animal waste affects water sources and poses health risks [48]. Inadequate infrastructure, including roads and sanitation facilities, hampers transportation and market access. The Proximity of humans and animals raises sanitation and disease concerns [49]. Limited veterinary services result in higher livestock mortality rates and reduced productivity. Market linkages and value chain integration are insufficient, hindering farmers' access to fair markets and value-added opportunities. Technical knowledge and training are lacking, impeding the adoption of modern farming practices.

6.7. Institutional limitations

Research institutes and experimental units face poor conditions due to inadequate employee training, insufficient budgets, and lack of farmer involvement [5]. Financial institutions provide limited support to small livestock farmers, leading to the need for microfinance. Livestock policies should focus on breeding animals to improve dairy productivity [50, 51]. Unfortunately, the country lacks facilities for training farmers in the latest technology, and technical training institutions don't provide quality information on livestock production problems.

6.8. The potential risks to breeds of livestock

Livestock diversity is declining due to environmental and societal factors [51]. In Pakistan, several potential threats, such as changing climate patterns, urbanization, diseases, inbreeding, loss of knowledge, and insufficient investment in breeding

programs and infrastructure, endanger the survival and genetic diversity of livestock breeds [52].

6.9. Limited services for the extension

Insufficient extension services in dairy production lead to low productivity due to farmers' reluctance to adopt modern technologies, limited investment, and high input costs [53, 54]. Proper extension services, efficient disease control programs, and good husbandry practices can enhance dairy animal production in remote areas [55]. However, extension personnel struggle to comprehend the actual needs of rural farmers, and programs that fail to enhance animal output are detrimental to livestock development [56].

6.10. Low production of dairy cows

The current animal productivity level is not enough to meet the rising demand for livestock products [57]. Pakistan lags behind other countries in terms of animal productivity per worker [58]. In Pakistan, it takes three dairy animals to produce the same amount of milk as one dairy animal in New Zealand. The reason for this difference in milk output is that the animal population is increasing at a faster rate than the resources required for livestock production.

6.11. Ineffective livestock services

The country's dairy animal and dairy farming departments are still operating at their original levels as veterinary services, offering limited health facilities and little animal production. The facilities are rendered by veterinarians with minimal education and skill sets and technicians with insufficient training [59]. They offer clinic-based services, but the extension staff has limited mobility. Consequently, less than 25% of the population can access animal health treatments. Breeding services are also scarce, as seen by the coverage of artificial insemination services, estimated to be no more than 3%, neglecting rural or isolated locations. Due to the government's lack of incentives for the livestock industry, livestock services have performed worse over time.

6.12. Inadequate growth of the milk processing sector

The poor development of the dairy industry in Pakistan poses significant challenges and hampers the growth and potential of the dairy sector [60]. One major issue is the lack of modern and efficient milk processing plants. The existing organization is characterized by its outdated amenities, lacking the advanced technologies needed for large-scale processing and production of value-added dairy products. The dearth of funds and resources hamper the establishment of new processing plants and the modernization of existing facilities [61]. The lack of robust infrastructure, including inadequate cold storage, transportation systems, and storage facilities, and the absence of rigorous quality control and standardization procedures also contribute to the underdevelopment of the milk processing sector [62].

6.13. Lack of policy

The absence of a comprehensive and well-executed policy framework for the dairy sector in Pakistan acts as a significant blockade to its growth and development [63]. Pakistan has witnessed the disappearance of over 36% of its indigenous livestock breeds due to the lack of vital conservation efforts and supportive government policies, according to a Food and Agriculture Organization (FAO) report. This alarming statistic highlights the pressing need for targeted policies to foster breed improvement and conserve genetic resources. The Pakistan Dairy Development Company reports that a significant amount of 85-90% of milk produced in the country remains raw and unprocessed [40], indicating the need for policy interpolations to boost processing ability. The absence of robust quality control and food safety regulations is also concern in the Pakistan dairy sector. A study led by the Pakistan Council for Scientific and Industrial Research (PCSIR) found that approximately 70% of sampled milk collected from different cities in Pakistan did not meet quality standards.

6.14. Breeds and breeding issues

Strategic breeding practices and breeding issues in the livestock sector play a pivotal role in the development and long-term sustainability of Pakistan's agricultural economy [64]. However, Livestock breed management in Pakistan faces challenges like genetic

erosion, loss of diversity, and inbreeding, leading to reduced productivity and disease susceptibility. The lack of farmer awareness and established breeding programs exacerbates these issues.

6.15. Limited access to Credit and Finance

The underperformance of research institutes can be attributed to various factors, including inadequate funding, underqualified staff, and low farmer involvement [65]. These institutions frequently provide technological packages that are incompatible with agricultural methods. Little loan support is available for small livestock farmers; most of it goes to influential people. Microfinance services and policies prioritizing animal breeding are necessary [66, 67]. The situation is particularly alarming in Baluchistan province, where no institution with the necessary capabilities can tackle these issues effectively. There are insufficient training facilities for technicians and farmers, especially regarding husbandry, feeding, and breeding.

6.16. Little understanding among small dairy farmers

Approximately 66% of rural population habitations depend on agriculture and animals [68]. They rely heavily on it as a primary source of income to meet their basic requirements. About 84 percent of small-scale dairy producers and their herds are in Pakistan's rural areas [69]. Britt, J. et al. state that 2.5 million dairy farms with a larger herd size can use current dairy equipment. However, most small dairy farmers lack education, are dogmatic, struggle to make ends meet, and are hesitant to adopt modern dairy practices because they are unaware of them [47].

6.17. Health and safety issues

Unsanitary production facilities and adulteration practices often compromise milk quality. Traditionally, boiling milk has been used to ensure safety for consumption. Poor hygiene, adulteration, and a broken cold chain produce low-quality milk. Public interest in milk supply chain safety has grown, making it a prominent issue in the dairy industry. It's crucial to examine safety failure factors in the dairy supply chain due to their direct impact on human consumption.

6.18. Dairy animals with great genetic potential as replacements

Replacing dairy heifers is vital for commercial dairy farming. Large farms often import seed stock from technologically advanced nations due to inadequate local breeding practices [70]. Replacing old genetic stock with new, high-milk-producing varieties is essential to maintain profitability. Importing livestock is costly and unsustainable, making local cultivation of replacement stock necessary. However, locally producing cost-effective, high-genetic-potential bovine heifers is challenging and requires significant research [71].

6.19. Factors to take into account with β-casein proteins

Casein, making up 80% of milk's protein, has various forms, with β-casein being the most common [72, 73]. The two main variants, A1 and A2, differ in their health impacts. A1, found in high quantities in Northern European breeds, releases the opioid-like B-casomorphin7 (BCM7) during digestion, potentially negatively affecting the body's neurological, endocrine, and immunological systems [74]. Some link A1 to health risks like autism, schizophrenia, type 1 diabetes, and coronary heart disease, though this is disputed [75]. The A1 and A2 milk controversy necessitates more precise research, including studies on various animal species. If A1-casein is proven harmless, it could significantly alter dairy farming practices globally.

6.20. Existence of antibiotics and Aflatoxins

6.20.1. Antibiotics

Antibiotic contamination in milk is a global subject, particularly in nations like Pakistan, where hygiene standards are low. Antibiotic residues refer to high levels of antibiotics or their derivatives in animal meat or byproducts. These residues pose direct health risks to humans, contaminate environmental resources, and interfere with dairy production [76]. International organizations, including the FAO, WHO, CAC, and EEC, aim to reduce antibiotic residues in milk and establish the standard maximum residual levels (MRLS) for animals and their products.

6.20.2. Mycotoxins

Aflatoxins, produced by Aspergillus species of fungi, are the most common mycotoxins found in various foods and feeds. These toxins are a global issue, especially in temperate regions where conditions favor fungal growth [77]. More than 20 different derivatives of aflatoxins exist, with acute exposure leading to high fatality rates [78]. However, most infections occur due to chronic exposure, affecting 4.5 billion people annually by weakening their immune systems [79]. The primary metabolite of aflatoxins in milk is aflatoxin M1, associated with severe health issues.

6.21. Factors to consider when comparing operating costs

Modern dairy operations involve high costs due to factors like elite livestock, feed ingredients, preventive medication, and electricity. These costs vary across milk production technologies and directly impact product pricing and profit margins [80]. Therefore, farmers must produce milk at lower costs to make Pakistan's dairy industry globally competitive. A pricing system per kg of milk production is also recommended, considering variations in species and milk production systems.

7. Proposed Strategies to Overcome Obstacles in the Dairy Sector

7.1. Adding value to dairy

Value-added dairy products provide benefits beyond essential nutrition. They can be flavored, fortified, or uniquely packaged. These products enhance the dairy industry's financial sustainability and competitiveness, opening new market opportunities and appealing to discerning consumers willing to pay a premium for tailored products [81].

7.2. Promoting the use of technology

Promoting technology in dairy farming increases efficiency and profitability. Precision farming uses sensors and data for optimal management. It monitors cow health milk production and identifies health issues early [82]. Automated milking systems reduce labor costs and improve efficiency [83]. Mobile apps provide real-time information on milk prices, market demand, and weather [84].

7.3. Modernizing supply chain management for success

Modern supply chain management is a great idea to encourage sustainable dairy practices [85]. Modern supply chain management can help minimize the environmental effects of dairy production by optimizing the manufacturing, handling, and transportation of milk and milk-derived products. In Figure 5, there is a proposed dairy supply chain model.

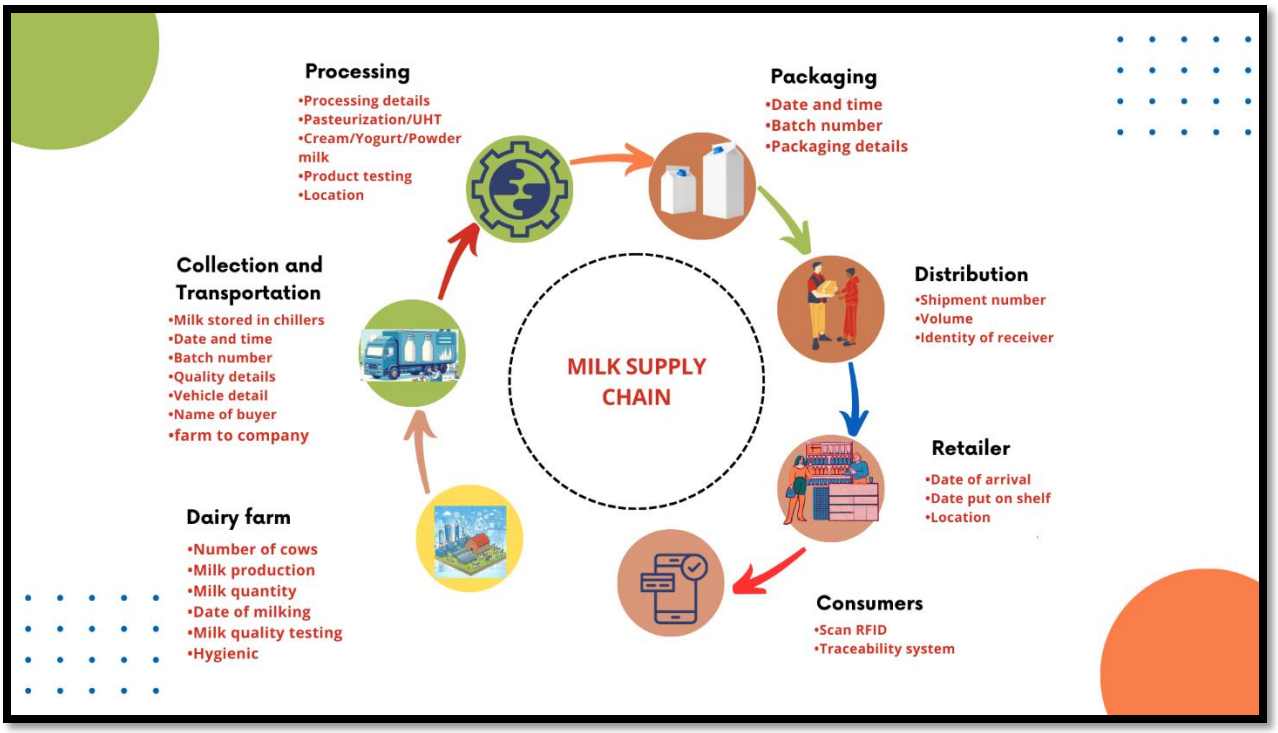

Figure 5: A proposed dairy supply chain model

7.4. Enhance range management

Effective dairy farming range management can be achieved through rotational grazing, infrastructure development, soil testing, reseeding, and monitoring [86]. Weed and pest control, expert partnerships, and community engagement are also crucial. Rangeland restoration and education further enhance sustainability, improving dairy production and environmental impact [87].

7.5. Improving animal health services

Enhancing animal health services is vital for Pakistan's dairy sector. This involves better veterinary care, vaccinations, disease prevention, regular health check-ups, and prompt treatment. Training veterinary professionals and public-private partnerships can improve service availability and affordability [88].

7.6. Improve market access

Enhancing market access is key for Pakistan's dairy farming. This includes infrastructure upgrades, stronger market connections, access to market data, policy engagement, and value addition. Better transport and cold chain facilities allow efficient product delivery. Stronger market links, accurate market data, and policy engagement help farmers secure better prices and access larger markets [89, 90].

7.7. Address peri-urban dairy challenges

Efficient strategies to tackle peri-urban dairy challenges in Pakistan include zoning regulations, proper waste management, improved herd management, farmer training, and collaboration with local authorities. These measures foster economic growth, ensure sustainable dairy farming, and enhance animal welfare and productivity [91].

7.8. Strengthen institutional support

Institutional support is crucial for Pakistan's dairy farming progress [92]. Farmers depend on organizations for advice, resources, and services, which enhance their knowledge and farming techniques. Access to modern technologies improves breeding, nutrition, and disease control. Farmer cooperatives facilitate group buying, marketing, and resource sharing. Enhanced institutional aid empowers farmers, increasing production, profits, and sustainability.

7.9. Protect livestock genetic diversity

Preserving livestock genetic diversity is essential for sustainable dairy farming. Artificial insemination (AI) is a vital tool in this, allowing controlled breeding with superior sires, maintaining genetic diversity, and preventing inbreeding [93, 94]. AI provides access to

high-quality genetics, improving the quality and productivity of dairy herds. By using AI responsibly and with proper selection criteria, farmers can preserve desirable traits and genetic diversity, ensuring long-term success in the dairy industry.

7.10. Foster milk industry

Fostering the milk processing industry requires creating modern processing plants, building solid relationships between producers and processors, investing in research and innovation, and receiving government assistance. These initiatives support the manufacturing of superior milk and dairy products, adapt to shifting consumer demands, and advance the economy.

7.11. Develop livestock guidelines

To achieve sustainable growth in Pakistan's livestock sector, it is essential to implement comprehensive policies, involve stakeholders, promote innovation, establish regulatory frameworks, and provide support to farmers [95]. The existing National Livestock Policy and Livestock and Dairy Development Policy have already contributed to increased milk production and the development of efficient milk collection and chilling systems. Further government initiatives are necessary to enhance the livestock industry further, which will ultimately improve Pakistan's food security and economic progress.

8. Conclusion

In summary, this chapter examined Pakistan's dairy industry, which comprises small holdings that engage in various farming practices. The dairy industry is operating sustainably to fulfill the needs of the expanding population regarding food. However, issues still need to be resolved for the dairy business soon, including local alternatives for dairy animals with high genetic traits, potential health concerns from B-casein proteins, antibiotics, and Aflatoxins consumption, and high operational costs. Gaining insight into the existing state of affairs and all possible solutions covered in this paper could facilitate addressing particular problems to overcome these obstacles.

Author Contributions

Conceptualization, F.S.; validation, F.S and M.A; writing—original draft preparation, Z.A, K.M, and A.G.; writing—review and editing, F.S, M.A and K.M; visualization, Z.A and A.G.

Acknowledgments

The authors are highly obliged to their library science department and institutes for access to journals, books and valuable database.

Conflicts of Interest

The authors declare no conflict of interest.

References

1. Kamal, A.B., et al., *Role of agriculture extension in ensuring food security in the context of climate change: State of the art and prospects for reforms in Pakistan.* Food Security and Climate-Smart Food Systems: Building Resilience for the Global South, 2022: p. 189-218.
2. Statistics., P.B.o., *Agriculture Statistics.* 2020.
3. Ullah, R., et al., *Isolation and molecular identification of enterotoxigenic strains of Escherichia coli in raw and pasteurized milk.* Sarhad Journal of Agriculture, 2022. **38**(5): p. 289-299.
4. Khalid, S.F., *Effect of technological innovation and application on SMEs in Pakistan: an overview of the dairy sector*. 2022: University of Wales Trinity Saint David (United Kingdom).
5. Abbas, Q., et al., *Adaptation to climate change risks among dairy farmers in Punjab, Pakistan.* Land use policy, 2022. **119**: p. 106184.
6. Groot, M.J. and K.E. van't Hooft, *The hidden effects of dairy farming on public and environmental health in the Netherlands, India, Ethiopia, and Uganda, considering the use of antibiotics and other agro-chemicals.* Frontiers in public health, 2016. **4**: p. 12.
7. Tahir, M.N., et al., *Current standing and future challenges of dairying in Pakistan: a status update.* Milk production, processing and marketing, 2019: p. 1-24.
8. Faraz, A., et al., *Socio-economic constraints on camel production in Pakistan's extensive pastoral farming.* Pastoralism, 2021. **11**(1): p. 1-9.
9. Riaz, M. *Livestock Integrated Farming in Rural Area of Pakistan*. in *International Conference on Improving Tropical Animal Production for Food Security (ITAPS 2021)*. 2022. Atlantis Press.
10. Makarabbi, G., et al., *Socio-economic Determinants Influence on NiliRavi Buffalo Farmers Choice of Milk Marketing Channels in Punjab.* Indian Journal of Extension Education, 2023. **59**(1): p. 112-116.
11. Wang, J., et al., *Adoption of Renewable Energy Technology on Farms for Sustainable and Efficient Production: Exploring the Role of Entrepreneurial Orientation, Farmer Perception and Government Policies.* Sustainability, 2023. **15**(7): p. 5611.
12. Tariq, M. and P.S.-C.T.T. Singh, *Sustainable Dairy Production in Pakistan: Lesson Learned and Way Forward.*
13. Tariq, M., *Practices of Clean Milk Production, Management and Decent Work in Faisalabad, Punjab, Pakistan.* 2022.
14. Husnain, S.N., et al., *Comparative quality analysis and economic feasibility of solar assisted yogurt processing unit for decentralized dairy value chain.* Scientific Reports, 2023. **13**(1): p. 6878.
15. Marghazani, I. *Proceedings and Abstract Book of the Sixth International Conference and Industrial Exhibition on*. in *Proceedings Sixth International Conference and Industrial*

Exhibition on Dairy Science Park, March. 2023. Islamia University Bahawalpur-63100, Pakistan.
16. Shahzad, M.A., *The need for national livestock surveillance in Pakistan.* Journal of Dairy Research, 2022. **89**(1): p. 13-18.
17. Sar, T., et al., *Potential utilization of dairy industries by-products and wastes through microbial processes: A critical review.* Science of the Total Environment, 2022. **810**: p. 152253.
18. Rahman, M.T., et al., *Influence of COVID-19 on the sustainability of livestock performance and welfare on a global scale.* Tropical Animal Health and Production, 2022. **54**(5): p. 309.
19. Darand, M., et al., *The association between dairy products and the risk of COVID-19.* European journal of clinical nutrition, 2022: p. 1-7.
20. Raza, A., et al., *Financial literacy and credit accessibility of rice farmers in Pakistan: Analysis for Central Punjab and Khyber Pakhtunkhwa regions.* Sustainability, 2023. **15**(4): p. 2963.
21. Akbar, M.O., et al., *IoT for development of smart dairy farming.* Journal of Food Quality, 2020. **2020**: p. 1-8.
22. Shahbaz, P., I. Boz, and S. ul Haq, *Adaptation options for small livestock farmers having large ruminants (cattle and buffalo) against climate change in Central Punjab Pakistan.* Environmental Science and Pollution Research, 2020. **27**: p. 17935-17948.
23. Ramírez-Rivera, E., et al., *Tropical milk production systems and milk quality: a review.* Tropical animal health and production, 2019. **51**(6): p. 1295-1305.
24. Thorsøe, M., et al., *Responding to change: Farming system resilience in a liberalized and volatile European dairy market.* Land Use Policy, 2020. **99**: p. 105029.
25. Safi, L., K. Sahak, and H. Mushwani, *Review of Afghanistan's Economic Development Status during Republic Government (from 2001-2021)*. International Journal of Multicultural and Multireligious Understanding, 2023. **10**(3): p. 99-109.
26. Organization, W.H., *WHO global strategy for food safety 2022-2030: towards stronger food safety systems and global cooperation*. 2022: World Health Organization.
27. Horst, A. and S. Watkins, *Enhancing Smallholder Incomes by Linking to High Value Markets in Pakistan's Punjab and Sindh Provinces.* 2022.
28. Afzal, A., et al., *Adulteration and microbiological quality of milk (a review)*. Pakistan Journal of Nutrition, 2011. **10**(12): p. 1195-1202.
29. Hoseinifar, S.H., et al., *Sustainable Ornamental Fish Aquaculture: The Implication of Microbial Feed Additives.* Animals, 2023. **13**(10): p. 1583.
30. Tauqir, N.A., et al., *Effect of Phosphorous and Phosphorous Plus Nitrogen Application on Nutritive Value and In situ Digestion Kinetics of Oat (Evena sativa) Grass in Nili Ravi Buffalo Bulls.* 2023.
31. Singh, N., et al., *Total Mixed Ration Feeding of Dairy Cows.*
32. Hussain, A., W. Akhtar, and A. Jabbar, *Risk management for small farmers in Pakistan: A review.* Pakistan Journal of Agricultural Sciences, 2022. **59**(2).
33. Rahman, A., et al., *Evaluation of Dried Citrus Pulp Addition to Total Mixed Ration in Replacement to Corn on Mutton Goat Performance and Health Indices.* Sustainability, 2023. **15**(8): p. 6584.
34. Niaz, S., et al., *Landuse impacts on soil organic carbon fractions in different rainfall areas of a subtropical dryland.* Archives of Agronomy and Soil Science, 2017. **63**(10): p. 1337-1345.
35. Nouman, W., et al., *Potential of Moringa oleifera L. as livestock fodder crop: a review.* Turkish Journal of Agriculture and Forestry, 2014. **38**(1): p. 1-14.

36. Jamil, A., M. Zubair, and B.A. Endress, *Influence of Pastoral Settlements Gradient on Vegetation Dynamics and Nutritional Characteristics in Arid Rangelands.* Sustainability, 2023. **15**(6): p. 4849.
37. Zafar, M., A. Tahir, and M. Rahim, *Lumpy Skin Disease.* One Health Triad, Unique Scientific Publishers, Faisalabad, Pakistan, 2023. **1**: p. 128-133.
38. Nadeem, M., et al., *Participatory Surveillance of Infectious and Non-Infectious Diseases of Livestock in Pakistan.* Punjab University Journal of Zoology, 2022. **37**(2): p. 143-148.
39. Organization, W.H., *A key role for veterinary authorities and animal health practitioners in preventing and controlling neglected parasitic zoonoses: A handbook with focus on Taenia solium, Trichinella, Echinococcus and Fasciola*. 2021: Food & Agriculture Org.
40. Tostivint, C., et al., *Measuring food waste in a dairy supply chain in Pakistan.* Journal of Cleaner Production, 2017. **145**: p. 221-231.
41. Jilte, R., et al., *A study on a milk chiller latent storage system with phase change material encapsulated spherical balls.* Journal of Energy Storage, 2023. **61**: p. 106783.
42. Barham, G., et al., *Frequent Supply of Adulterated Milk at Southern Zone of Sindh, Pakistan.* J Dairy Res Tech, 2018. **1**(002).
43. Muhammad, Z., S.N. Akhter, and M.K. Ullah, *Dairy supply chain management and critical an investigations on dairy informal channel partners in Pakistan.* IOSR Journal of Business and Management, 2014. **16**(3): p. 81-87.
44. Hoffmann, V., C. Moser, and A. Saak, *Food safety in low and middle-income countries: The evidence through an economic lens.* World Development, 2019. **123**: p. 104611.
45. Handford, C.E., K. Campbell, and C.T. Elliott, *Impacts of milk fraud on food safety and nutrition with special emphasis on developing countries.* Comprehensive Reviews in Food Science and Food Safety, 2016. **15**(1): p. 130-142.
46. Rehman, A., et al., *Livestock production and population census in Pakistan: Determining their relationship with agricultural GDP using econometric analysis.* Information Processing in Agriculture, 2017. **4**(2): p. 168-177.
47. Britt, J., et al., *Invited review: Learning from the future—A vision for dairy farms and cows in 2067.* Journal of dairy science, 2018. **101**(5): p. 3722-3741.
48. Ukaogo, P.O., U. Ewuzie, and C.V. Onwuka, *Environmental pollution: causes, effects, and the remedies*, in *Microorganisms for sustainable environment and health*. 2020, Elsevier. p. 419-429.
49. Espinosa, R., D. Tago, and N. Treich, *Infectious diseases and meat production.* Environmental and Resource Economics, 2020. **76**(4): p. 1019-1044.
50. Brito, L., et al., *Genetic selection of high-yielding dairy cattle toward sustainable farming systems in a rapidly changing world.* Animal, 2021. **15**: p. 100292.
51. Xie, H., et al., *Prospects for agricultural sustainable intensification: A review of research.* Land, 2019. **8**(11): p. 157.
52. Ober, E.S., et al., *Wheat root systems as a breeding target for climate resilience.* Theoretical and Applied Genetics, 2021. **134**(6): p. 1645-1662.
53. Vyas, D., et al., *MILK Symposium review: Identifying constraints, opportunities, and best practices for improving milk production in market-oriented dairy farms in Sri Lanka.* Journal of dairy science, 2020. **103**(11): p. 9774-9790.
54. Angello, C.K., *Adoption and use of ICTs by Livestock Keepers for improved access to Livestock Information: A case of selected urban areas in Tanzania*, in *Developing Countries and Technology Inclusion in the 21st Century Information Society*. 2021, IGI Global. p. 246-268.
55. Nikam, V., A. Ashok, and R.B. Kale, *The functionality of agricultural extension and advisory services from a system perspective: a subnational level analysis in India.* The Journal of Agricultural Education and Extension, 2022: p. 1-25.

56. Pousga, S., et al., *Extension Services for Livestock Keepers in Low-Income Countries—A Low Priority?* Animals, 2022. **12**(6): p. 726.
57. Ijaz, M., et al., *Meat production and supply chain under COVID-19 scenario: Current trends and future prospects.* Frontiers in Veterinary Science, 2021. **8**: p. 660736.
58. Ghafar, A., et al., *A participatory investigation of bovine health and production issues in Pakistan.* Frontiers in Veterinary Science, 2020. **7**: p. 248.
59. Farooq, U., et al., *Accreditation and evaluation of veterinary medical institutes–a Pakistani perspective.* Rev. Sci. Tech. Off. Int. Epiz, 2018. **37**(3): p. 2.
60. Gopal, N. and D. Panchal, *Reliability based framework for failure analysis in milk process industry.* Decision Making: Applications in Management and Engineering, 2023. **6**(1): p. 631-645.
61. Yaseen, A., S. Somogyi, and K. Bryceson, *Entrepreneurial behaviour formation among farmers: evidence from the Pakistani dairy industry.* Journal of Agribusiness in Developing and Emerging Economies, 2018.
62. Khyzer Bin Dost, M., et al., *The impact of knowledge management's practices on supply chain performance of the dairy sector in Central Punjab: a mediating role of decentralization.* Economic research-Ekonomska istraživanja, 2018. **31**(1): p. 290-312.
63. Rana, A.W., *Institutional assessment and change: Department of agriculture, government of the Punjab, Pakistan*. 2021: Intl Food Policy Res Inst.
64. Bashir, M.K., et al., *Inbreeding Effect on Productive, Reproductive and Lifetime Traits of Nili-Ravi Buffaloes.* Pakistan Journal of Life & Social Sciences, 2019. **17**(1).
65. Razzaq, S., N. Maqbool, and W.U. Hameed, *Factors effecting the elasticity of micro credit demand in southern Punjab, Pakistan.* International Journal of Social Sciences and Economic Review, 2019. **1**(2): p. 46-53.
66. Jabbar, A., et al., *Tick-borne diseases of bovines in Pakistan: major scope for future research and improved control.* Parasites & vectors, 2015. **8**(1): p. 1-13.
67. Ali, A., M. Ahmed, and N. Hassan, *Socioeconomic impact of COVID-19 pandemic: Evidence from rural mountain community in Pakistan.* Journal of Public Affairs, 2021. **21**(4): p. e2355.
68. Qaisrani, A., et al., *What defines livelihood vulnerability in rural semi-arid areas? Evidence from Pakistan.* Earth Systems and Environment, 2018. **2**: p. 455-475.
69. Sattar, A., *What is Holding Back Milk Production Potential in Pakistan?* 2022.
70. De Vries, A. and M. Marcondes, *Overview of factors affecting productive lifespan of dairy cows.* Animal, 2020. **14**(S1): p. s155-s164.
71. Gosey, J., *Beef cattle selection opportunities for net merit*, in *Beef Cattle Science Handbook*. 2019, CRC Press. p. 370-375.
72. Kelleher, C.M., et al., *The effect of protein profile and preheating on denaturation of whey proteins and development of viscosity in milk protein beverages during heat treatment.* International Journal of Dairy Technology, 2020. **73**(3): p. 494-501.
73. Pandey, A., M. Thakur, and Y. Pandey, *Polymorphism of beta (β) casein gene and their association with milk production traits in Malvi and Nimari breeds of cattle.* Indian Journal of Animal Research, 2020. **54**(5): p. 647-650.
74. Demirel, A.F. and Ç. Bahattin, *Discussions of effect A1 and A2 milk beta-casein gene on health.* proteins, 2018. **8**: p. 9.
75. Cieślińska, A., et al., *Genetic polymorphism of β-Casein gene in Polish Red Cattle—Preliminary study of A1 and A2 frequency in genetic conservation herd.* Animals, 2019. **9**(6): p. 377.
76. Ben, Y., et al., *Human health risk assessment of antibiotic resistance associated with antibiotic residues in the environment: A review.* Environmental research, 2019. **169**: p. 483-493.

77. Loi, M., et al., *Plant bioactive compounds in pre-and postharvest management for aflatoxins reduction.* Frontiers in Microbiology, 2020. **11**: p. 243.
78. Dhakal, A. and E. Sbar, *Aflatoxin toxicity.* 2020.
79. Kemboi, D.C., et al., *A review of the impact of mycotoxins on dairy cattle health: Challenges for food safety and dairy production in sub-Saharan Africa.* Toxins, 2020. **12**(4): p. 222.
80. Bojovic, M. and A. McGregor, *A review of megatrends in the global dairy sector: what are the socioecological implications?* Agriculture and Human Values, 2023. **40**(1): p. 373-394.
81. Kashyap, D. and S. Bhuyan, *Accessing value-added market through cooperatives: a case study of Sitajakhala Dugdha Utpadak Samabai Samiti Ltd., India.* Journal of Agribusiness in Developing and Emerging Economies, 2021.
82. Monteiro, A., S. Santos, and P. Gonçalves, *Precision agriculture for crop and livestock farming—Brief review.* Animals, 2021. **11**(8): p. 2345.
83. Matson, R., et al., *Benchmarking of farms with automated milking systems in Canada and associations with milk production and quality.* Journal of Dairy Science, 2021. **104**(7): p. 7971-7983.
84. Barrios, D., M. Olivera-Angel, and L.G. Palacio, *Factors associated with the adoption of mobile applications (Apps) for the management of dairy herds.* Revista de Economia e Sociologia Rural, 2023. **61**.
85. Kshetri, N., *Blockchain and sustainable supply chain management in developing countries.* International Journal of Information Management, 2021. **60**: p. 102376.
86. Vaintrub, M.O., et al., *Precision livestock farming, automats and new technologies: Possible applications in extensive dairy sheep farming.* Animal, 2021. **15**(3): p. 100143.
87. Hamadeh, S., *Can Sustainable Pasture Management Improve the Ecosystem Services for Small Ruminant Farmers and Rural Communities? A Case Study from West Bekaa, Lebanon*. 2023.
88. Kumar, V. and H. Meena, *Role Perception and Performance of Privately Practicing Paravets in Delivery of Animal Health Services at Farmers' Doorstep: an Exploratory Study in India.* Tropical Animal Health and Production, 2021. **53**: p. 1-20.
89. Nandi, R., S. Nedumaran, and P. Ravula, *The interplay between food market access and farm household dietary diversity in low and middle income countries: a systematic review of literature.* Global Food Security, 2021. **28**: p. 100484.
90. Ndlovu, P., J. Thamaga-Chitja, and T. Ojo, *Factors influencing the level of vegetable value chain participation and implications on smallholder farmers in Swayimane KwaZulu-Natal.* Land Use Policy, 2021. **109**: p. 105611.
91. Ahani, S. and H. Dadashpoor, *Land conflict management measures in peri-urban areas: A meta-synthesis review.* Journal of Environmental Planning and Management, 2021. **64**(11): p. 1909-1939.
92. Totin, E., B. van Mierlo, and L. Klerkx, *Scaling practices within agricultural innovation platforms: Between pushing and pulling.* Agricultural Systems, 2020. **179**: p. 102764.
93. Tadesse, B., et al., *Success rate of artificial insemination, reproductive performance and economic impact of failure of first service insemination: a retrospective study.* BMC Veterinary Research, 2022. **18**(1): p. 1-10.
94. Schultz, B., N. Serão, and J.W. Ross, *Genetic improvement of livestock, from conventional breeding to biotechnological approaches*, in *Animal Agriculture*. 2020, Elsevier. p. 393-405.
95. D'agostino, D., et al., *Multi-stakeholder analysis to improve agricultural water management policy and practice in Malta.* Agricultural water management, 2020. **229**: p. 105920.