Bhutan Journal of Animal Science (BJAS)
Volume 6, Issue 1, Page 34-39, March 2022

A TIME-SERIES ANALYSIS OF DAIRY PRODUCTION IN PUNAKHA DISTRICT

PEMA UGYEN

District Livestock Sector, District Administration, Punakha, Bhutan

Author for correspondence: lingmapong@yahoo.com

ABSTRACT: Time-series analysis is a measurement of values at a time period. The study was undertaken to forecast time-series data of the dairy cattle population and milk production for future planning and decision-making purposes. The study used secondary data source of Punakha district for the period of 15 years (2006-2020). The Autoregressive Integrated Moving Average (ARIMA) models using the forecasting command of SPSS version 25 were used for trend analysis and predicting values for the coming decade. The model estimated that the improved cattle population will increase by 48.39 percent, while the local cattle population is expected to decrease by 3.41 percent. During the same period, the overall cattle population is shown to increase by 15.29 percent. It is estimated that the growth rate for milk production will grow by 34.80 percent. Despite the growth in improved cattle population and milk production, the milk self-sufficiency is predicted to decline to 54.33 percent in 2030 from 64.47 percent in 2020. Considering the current average daily milk production of 1.99 litres per cow, the district would require 4240 milking cows to produce 2560 metric tonnes of milk at the end of project period. However, if milk productivity is to be optimized to 4 litres per cow per day, 2112 milking cows in the district is enough to produce 2560 metric tonnes of milk. This is a decrease of 8.3 percent milking cattle population over the decade. Based on the outcomes of this study, there is a need to strengthen the application of artificial insemination technology as the main driving force for the steady increase in crossbreed dairy cattle population, initiate a co-governance system working modality where every stakeholder accepts and plays an important role in mainstreaming dairy value chain and encourage farmers for proper herd management, better health care facitities for high yielding dairy animals. The extension arm should play a critical role and provide effective and efficient livestock services to the farmers for enhancing the productivity of high yielding dairy animals.

Keywords: Dairy; district; forecasting; milk; time-series

1. INTRODUCTION

Bhutan continues to witness tremendous growth in the dairy sector since the start of the First Five Year Plan in 1961. The dairy sector has proved to be resilient during the COVID-19 pandemic situations and was not as significantly impacted compared to other sectors (Food and Agriculture Organization [FAO] 2021). Dairy provides livelihood opportunities for farmers, middlemen, processors, retailers, and other stakeholders in the dairy value chain (Muehlhoff et al. 2013). The country's major improvement in dairy development consists of cattle crossbreeding with exotic dairy breeds, farmers' group formation, and mainstreaming the dairy value chain along the chain functions. Milk production has increased from 21,437 metric tonnes in 2006 (Department of Livestock [DoL] 2006) to 57,912 metric tonnes in 2020 (Renewable Natural Resources Statistics Division [RNR-SD] 2021). Currently, the self-sufficiency rate for fresh milk, butter, and cheese combined is reported at 88.15 percent (DoL 2021). Likewise, the per capita availability of milk has also increased from 113 grams/day in 2012 to 219 gram/day in 2020 against the FAO recommended daily allowance of 200gm/person/day. There is a clear indication that the dairy sector in Bhutan is growing over the years.

Dairy farming in Punakha is a socially acceptable and economically sound compared to other livestock activities. The setbacks for other livestock sub-sectors are religious stigma,

economic and environmental factors among others. The annual livestock statistics 2020 (RNR-SD 2021) shows that about 34 percent of the total 6079 households' families in Punakha own dairy cattle. The total cattle population was recorded as 11,192 heads with improved dairy cattle of jersey and Brown Swiss breeds accounting to 26.37% of the total cattle population in the year 2020. On an average, each household rear 6 heads of dairy cattle either for milk, manure and draught power purposes. The report also showed that close to 1391 metric tons of milk was being produced in 2020. As of 2020, number of milking cow population in the district was 2304 heads that accounts 52% local breeds and other 48% crossbreds milking cows. As reported by Wangdi et al. (2014), and considering the mean lactation record of 303 days for the dairy breeds and their crossbreds in Bhutan, the average daily milking production in the district was recorded at 1.99 litres per cow per day. The per capita availability of milk in 2020 in the district stands at 128 grams/person/day against the FAO recommended allowance of 200gm/person/day. The human population of the district was estimated at 29,557 with a population density of 26.63 per sq.km (Punakha Dzongkhag 2020). However, till date, very limited information is available to forecast time-series data on dairy cattle population and milk production for future planning and decision-making purposes. Therefore, this study was designed to capture information for devising trend analysis of milk production and forecast future values based on statistical models for accurate future predictions, sustainable production, and policy decisions in the district.

2. MATERIALS AND METHODS

2.1 Data collection

The study was conducted for Punakha District using a secondary data source (Figure 1). The data of annual livestock population and production of Bhutan from 2006 to 2020 time period were obtained from Livestock Statistics reports maintained by the Department of Livestock and Renewable Natural Resources Statistics Division under the Ministry of Agriculture & Forests, Bhutan. These data sets are obtained during the

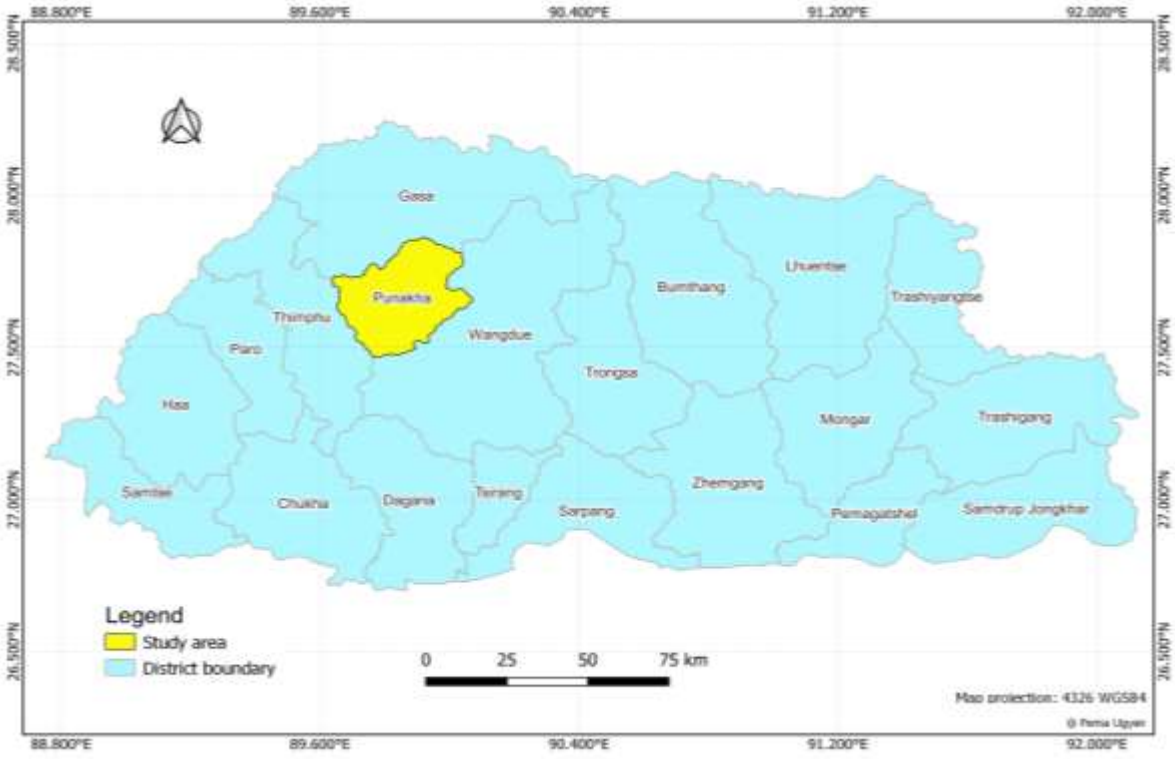

Figure 1: Map of study area

annual livestock census conducted for each household by Extension staff of the Block. The district is administratively divided into eleven blocks.

2.2 Data Analysis

The time series analysis method was employed for analyzing the secondary data. "A time-series forecasting is a sequential set of data points, measured typically over successive times" (Cochrane 1997). It is mathematically defined as a set of vectors $x(t) = 0, 1, 2,\ldots$ where t represents the time elapsed". The variable $x(t)$ is treated as a random variable, and the measurement is taken during an event in a time-series arranged in a proper chronological order.

The statistical analysis was performed using the forecasting command of the statistical package for social science (SPSS) version 25.

2.2.1 Model identification

To determine how the observations in a time series data are related to each other and make decisions on the models to be used, Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) analysis were carried out. ACF determines the correlation between the observation at the current time spot and observation at the previous times spot, while, PACF determines the correlation between observations at two-time spots given that we consider both observations have relationships to observations at other time spots.

2.2.2 ARIMA model

Autoregressive Integrated Moving Average (ARIMA) models were employed to forecast the dairy cattle population and milk production in the district. This model considers only one variable under each observation and can be used for stationary time series data. The ARIMA model was also useful in capturing the pattern and making a forecast of future expected value.

The advantage of the ARIMA model is that a non-stationary time series is made stationary by applying finite differencing of the data points. In the ARIMA method, these three parameters (p, d, q) are taken into account where p refers to the order of the autoregressive, d is the order of differencing and q is the order of the moving average respectively (Ordu and Zengin 2020). Thus, the result obtained from this model could be used to model and forecast the future milk demand in the district.

3. RESULTS AND DISCUSSION

In this study, the Punakha district dairy cattle population and milk production from 2006-2020 was analyzed and predictive values were obtained until 2030 using the ARIMA model. The appropriate model used for this analysis was ARIMA (1, 0, 0) to obtain the point of the forecast.

3.1 Cattle population

The cattle population trends and forecasts over the coming decade are presented in Figure 2. The local cattle population is expected to decrease to 6873 heads in 2030 from 7119 cattle heads in 2020. There will be a marginal decrease of 3.41 percent over the coming decade or a 0.34 percent decrease per annum.

The improved cattle population is projected to upsurge by 48.39 percent over the coming decade reaching 6044 numbers by 2030. Annually, the growth in the number of the improved cattle

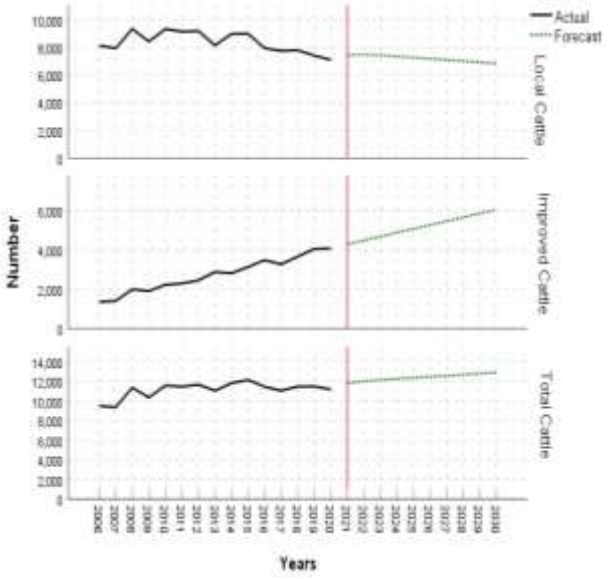

Figure 2: Cattle population trend and forecasts

population is forecasted at 4.84 percent per annum. Similarly, the overall cattle population is projected to grow from 11,192 cattle heads in 2020 to 12,893 cattle heads in 2030. The growth rate is projected to increase by 1.53 percent per annum and 15.29 percent over the coming decade.

Projection of cattle population into the future is valuable for planning and decision making, particularly for the district administration and service providers such as the District Livestock Sector (DLS). This will enable district and block livestock staff to plan and design projects, together with relevant authorities including District and Department of Livestock, either increase or decrease in cattle population. This will help DLS to implement interventions that will help achieve milk requirement in the district and have surplus to market for enhancing income and livelihood of livestock keepers. This study forecasted an increasing number of improved cattle and total cattle population, while the local cattle population was projected to decrease annually (Table 1). This was obvious as Bhutan aims to intensify livestock production through crossbreeding programs to meet the increasing demands of livestock products through domestic production (Samdup et al. 2013).

The cattle breed intensification through crossbreeding program has resulted in the reduction of local cattle numbers per farm. Though Artificial Insemination (AI) program is a promosing breeding technology, majority of the dairy farmers still prefer cattle breeding using breeding bulls supplied by the government or those owned by private individuals (Dendup and Dorji 2020). Similarly, Thapa et al. (2020) had reported the challenges encountered in the smallholder system on lack of technology adoption for breeding, fodder conservation, and marketing support. Getting easy access to AI services could accelerate the breed intensification program and increase in milk production. The breed intensification program will also support in replacing farm nutrient flows from common property resources with nutrient inputs through increased use of commercial cattle concentrate and conserved fodder. It is crucial to bring the livestock density in line with the carrying capacity of the farmland. The policy of importing dairy cattle has not seen a tangible impact at least in the study area in keeping high-yielding dairy cows by the smallholder dairy farmers. Crossbreeding programs through the use of AI services and breeding bulls in areas having less access to farm road will reduce dairy imports, increase high yielding and higher longevity of dairy animals, and will reduce environmental impact on forests and other common property resources. This is in agreement with the findings of Rai et al. (2020) confirming that breed improvement breakthroughs have been met through AI services in the Contract Heifer and Bull Production Program with 95% Confidence Interval.

3.2 Milk production

Milk production is projected to increase by 34.80 percent over the coming decade (Figure 3). The average annual growth rate during the projection period is expected at 3.48 percent from 1391 metric tonnes in 2020 to 1875 metric tonnes in 2030.

Table 1: Forecasted values of cattle population

Model		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total cattle (No.)	Forecast	11802	12019	12149	12260	12367	12472	12577	12683	12788	12893
	UCL	13294	13547	13679	13790	13896	14002	14107	14212	14318	14423
	LCL	10311	10492	10620	10731	10837	10942	11048	11153	11258	11363
Improved cattle (No.)	Forecast	4303	4482	4684	4875	5071	5265	5460	5655	5850	6044
	UCL	4577	4783	4989	5182	5378	5572	5767	5962	6156	6351
	LCL	4028	4181	4378	4569	4765	4959	5153	5348	5543	5737
Local cattle (No.)	Forecast	7461	7503	7454	7378	7293	7206	7118	7029	6941	6852
	UCL	8851	8957	8914	8838	8753	8666	8578	8489	8401	8312
	LCL	6070	6049	5995	5918	5833	5746	5657	5569	5481	5392

Table 2: Forecasted values of milk production with 95% Confidence Interval

Model		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Milk production (MT)	Forecast	1448.59	1498.42	1546.16	1593.36	1640.40	1687.41	1734.40	1781.39	1828.39	1875.38
	UCL	1707.02	1765.87	1814.25	1861.49	1908.54	1955.54	2002.54	2049.53	2096.52	2143.51
	LCL	1190.16	1230.96	1278.08	1325.23	1372.27	1419.27	1466.27	1513.26	1560.25	1607.24

Based on the current findings, it is clear that there was an increase in milk production in the district. However, considering the growth of only 3.48 percent per annum which were mainly from increasing crossbreeds' dairy cattle and its productivity, the milk production growth rate was forecasted to be at a slower pace and will be far behind achieving self-sufficiency in the district. Considering the annual human population growth of 35,073 people in the year 2032 (National Statistical Bureau 2019), the district requires 2560 metric tonnes of milk, while the forecast was just over 1875 metric tonnes of milk production. The Upper Control Limit (UCL) and Lower Control Limit (LCL) was estimated at 2143 metric tonnes and 1607 mettric tonnes of milk production respectively at the end of the projected period (Table 2).

The milk self-sufficiency rate is estimated to decline at 54.33 percent in 2030 compared to 64.47 percent in 2020. Considering current milk production of 1.99 litres per cow per day, the district would require 4240 milking cows to produce 2560 metric tonnes of milk at the end of project period.

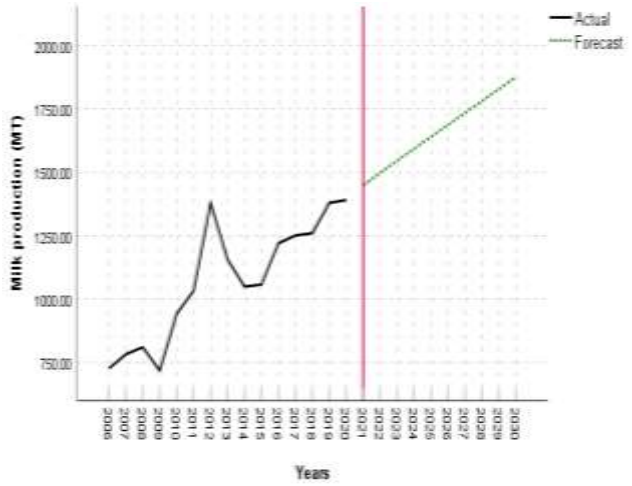

Figure 3: Milk production trends and forecasts

The best possible option would be to increase milk yield per cow per day rather than increasing the cattle population that will only contribute towards total Greenhouse Gas (GHG) emissions over the life cycle of milk and other dairy products. If milk productivity is to be optimized to 4 litres per cow per day, the district is enough with 2112 milking cows to produce 2560 metric tonnes of milk at the end of projected period. This is decreased of 8.3 percent in milking cattle population over the decade. The drivers for increased milk production include optimizing the milk productivity per animal, better genetics gain, improved animal health, and improved efficiencies in feeds and feeding (FAO 2021). The district should be mindful of the climate change and should adopt climate-smart livestock farming and mitigation measures such as improving animal feeds, promoting stall feeding practices, manure management, animal health, herd productivity to improve dairy productivity and reduce the rate of GHG emissions intensity from dairy farming.

4. CONCLUSIONS & RECOMMENDATION

This study was an attempt to forecast and understand how dairy production in Punakha district is positioned to achieve milk requirement in the district within the next decade. The study was based on annual dairy population and milk production trends using statistical models for accurate future predictions under business as usual (BAU) situation.

The most significant findings are slow pace of increment on the milk production and worrisome forecasted values of milk self-sufficiency rate in the district. Without proper policy interventions and aggressive extension services, the milk production targets will remain unachieved in the district. Therefore, the outcomes of this study suggest the following interventions at farm and policy levels.

Farm-level interventions

- Encourage proper dairy herd management with high yielding breeds of dairy animals to enhance milk productivity/animal.
- Provide balanced nutrition and high quality forage to commensurate animal requirements for maintenance and production.
- Provide due attention to timely heat detection and AI services preferably using sex sorted pure Jersey semen.
- Provision for improved housing system and better health care facilities to dairy animals.

Policy level interventions

- Provide concerted effort on training and advocacy for proper management mainly fousing on nutrition, reproduction and health management to improve productivity per animal
- Provide strategic directives to strengthen application of Artificial Insemination technology (promotion of sexed sorted semen) as the main driving force for faster genetic gain in the cattle and to increase milk production.
- Ensure active participation of Local Governments (LG) in mainstreaming dairy sector development in their plans and programs and provide fund and other administrative support to strengthen dairy value chain in the district.

REFERENCES

Cochrane JH. (1997). Time Series for Macroeconomics and Finance, Chicago: University of Chicago.

DoL. (2006). Livestock Statistics 2006, Department of Livestock, Thimphu:

DoL. (2021). Livestock Research Strategy, Operational Modalities and Implementation Guidelines, Thimphu, Bhutan: Department of Lievstock .

FAO. (2021). Dairy and dairy products, Rome, Italy: Food and Agriculture Organisation

Muehlhoff E, Bennett A and McMahon D. (2013). Milk and dairy products in human nutrition, Rome, Italy: Food and Agriculture Organisation [FAO].

National Statistical Bureau (2019). Dzongkhag Population Projections 2017-2027, Thimphu, Bhutan: National Statistical Bureau of Bhutan.

Ordu M and Zengin Y. (2020). A comparative forecasting approach to forecast animal production: A case of Turkey. Livestock Studies, 60(1): 25-32.

Punakha Dzongkhag (2020). Dzongkhag Administration, Punakha. [Online] Available at: http://www.punakha.gov.bt/en/downloads?Type=24&Sector=All [Accessed 18 2 2022].

RNR-SD. (2021). Annual Livestock Statistics 2020, Thimphu, Bhutan: Renewable Natural Resources Statistics Division, Directorate Services.

Samdup T, Udo HMJ, Viets TC and Zijpp AJ van der. (2013). Livestock intensification and use of natural resources in smallholder mixed farming systems of Bhutan. Livestock Research for Rural Development. Volume 25, Article #114. Retrieved February 19, 2022, from http://www.lrrd.org/lrrd25/7/samd25114.htm

Wangdi J, Mindu, Bhujel P, Karma and Wangchuk S. (2014). Productive and reproductive performance of dairy cattle and their crossbreds in Bhutan. Livestock Research for Rural Development. Volume 26, Article #181. Retrieved February 19, 2022, from http://www.lrrd.org/lrrd26/10/wang26181.htm