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Trends in growth-instability matrix and strategies for sustainable buffalo milk production

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ABSTRACT

The study was conducted on secondary data which was collected from various published reports such as Basic Animal Husbandry Statistics (BAHS), BAHS Annual reports, Livestock census and State Department of Animal Husbandry (SDAH) annual reports. The results of the study revealed that the growth rate of milch buffaloes was significantly higher than the growth rate of milk productivity. The results of growth-instability matrix for the milch population, milk production and productivity of states was put into four different quadrants such as positive growth & low instability, positive growth & high instability index, negative growth & low instability and negative growth & high instability index. Further states were classified into four categories such as High Milch Population & High Milk productivity (HPHP), High Milch Population with Low Milk Productivity (HPLP), Low Milch Population with High Milk Productivity (LPHP) and Low Milch Population with Low Milk Productivity of buffaloes (LPLP) based on mean values. In this study the state with negative growth rate and high instability index for milch population and milk productivity needs to be strengthened and stabilized for better and continuous milk production. The states classified under Low Milch Population and Low Milk Productivity of buffaloes (LPLP) has to be given more attention to address the declining milch buffalo population. There is need to adopt suitable breeding policy and strategy to upgrade the non-descript low milk yielding

buffaloes by using superior germplasm for sustainable buffalo milk production and productivity.

Key words: Buffaloes, Growth, Instability, Milch population, Production and Productivity

INTRODUCTION

Asian or water buffalo (*Bubalus bubalis*) holds greatest promise for food security and sustainable development in Asian countries as this animal is used for milk, draught and meat purpose. Food and Agricultural Organization (FAO, 2000) termed buffalo as an important asset that is undervalued. Currently, there are 208 million buffaloes spread across 77 countries; in which about 97 per cent of the buffaloes in the world found in Asian continent and contributes about 100.74 million tons of milk and produces 2/3rd of meat. Among Asian countries about 56.67 per cent of buffaloes are habitant in India followed by Pakistan (19.28%) and China (13.46%). India has world's largest Buffalo population with 109.85 million headcounts constituting 20.45 per cent to the livestock population (20th livestock census, 2019). Indeed buffaloes are considered as the backbone of commercial dairying in India due to their fat rich, low cholesterol milk production potential and plays crucial role in rural livelihood, food security and agriculture economy.

In India, buffaloes are preferred over cattle in many parts of the country owning to its superior quality of milk, disease resistance, longer productive life and higher milk productivity. According to 20th Census buffalo population is less as compared to cattle (192.49 million), but share of buffalo milk production is higher than the indigenous and crossbred cows. Buffaloes contribute about 49 per cent in total milk production with production of 91.82 MT in 2018-19. India endowed with rich bio-diversity of buffalo germplasm in the form of 17 recognized breeds and several non-descript type. Despite availability of diverse germplasm, the majority of Indian buffaloes are low producing. At times, milk productivity is marred by suboptimal reproductive efficiency and lack of quality feed resources. Therefore, there is great scope and opportunity for further improvement in genetic potential of buffalo for milk production. Besides accelerated improvement of genetics and reproductive efficiency, development of technologies for better utilization of feeds and fodders hold the promise for overall improvement in buffalo productivity. While on the one hand we have to provide solutions to the current problems facing buffalo farmers and improve production, productivity and income of the farmers.

In recent times, the demand for milk and milk products among rural and urban consumers increased significantly. The projected growth in annual income, urbanization and human population are the important factors determining demand for livestock products in developing countries. The expenditure on milk and milk products increased from 11.66 to 18.72 per cent and 14.89 to 20.26 per cent in rural and urban areas, respectively from 1970-71 to 2011-12 (25th & 68th NSSO survey). The demand for milk

and milk products will increase significantly as the estimated population of India will be 1.61 billion by 2050. Although in India per capita availability of the milk is much higher than the World Health Organisation (WHO) recommendations, but the demand is likely to rise further and with the target to produce total milk production of 400 million tonnes by 2050. The increased demand for milk and milk products can be met through buffalo milk production, because the share of buffalo milk in total milk production is highest as well as buffalo milk has advantage over cow milk not only in terms of physicochemical, compositional, and sensory attributes, but also in its nutritional and health aspects (Mane et al., 2015). Therefore, buffaloes play very vital role in milk production and have opened new avenues for the dairy farmers to reap the benefits by supplying the quality milk and milk products at reasonable price. Therefore, there is a need to understand growth rate and extent of instability in the milch population, milk production and productivity of buffaloes among different Indian states. It will further help in framing new policies and strategies for enhancement of milk production, productivity and income of the farmers.

MATERIALS AND METHODS

For the study, secondary data was collected on milch buffalo population, milk production and milk productivity of buffalo for the year 1999-00 to 2018-19 from various published reports such as Basic Animal Husbandry Statistics (BAHS), BAHS Annual reports, Livestock census and State Department of Animal Husbandry (SDAH) annual reports. The data of Telangana has been taken from 2014 after its bifurcation from Andhra Pradesh.

The Compound Annual Growth Rate (CAGR) and Instability (Cuddy-Della Valle Index) techniques were used to analyze the growth rate and instability in milch buffalo population, milk production and productivity of buffaloes in different states.

1. Compound Annual Growth Rate (CAGR)

To calculate the annual growth rate of milch population, milk production and productivity of the buffaloes, the following formula (Sendhil *et al.*, 2012 and Balaganesh *et al.*, 2019) is used.

$$Y_t = Y_O(1+r)^t \quad \text{.....} \qquad (1)$$

Take log on both sides and transform to logarithmic form.

$$\ln Y_t = \ln Y_O + t\ln(1+r) \quad \text{.....} \qquad (2)$$

Where,

Y_t= Variable for which growth is calculated.

r = Compound growth rate.

ln= Natural logarithm.

Take, $\ln Y_0 = \beta_1$ and $\ln(1+r) = \beta_2$

Then, equation (2) becomes,

$$\ln Y_t = \beta_1 + \beta_2 t \quad \ldots\ldots\ldots\ldots\ldots \quad (3)$$

Here, β_1 and β_2 are estimated by Ordinary Least Square (OLS) method and the CAGR is estimated by, $r = (anti\log \beta_2 - 1) \times 100$

2. Coefficient of Variation (CV)

To calculate variations in milch population, milk production and productivity of the buffaloes, Coefficient of Variation (CV) is used.

$$CV = (SD / MEAN) \times 100 \quad \ldots\ldots\ldots \quad (4)$$

Where,

CV= Coefficient of variation in per cent

SD= Standard Deviation of the observations

MEAN= Mean of the observations

3. Instability (Cuddy-Della Valle Index)

To estimate the instability in milch population, milk production and productivity of the buffaloes, the Cuddy-Della Valle Index (Cuddy and Della Valle, 1978) has been used. It helps to know the variability and risk in those variables.

$$\text{Cuddy-Della Valle Instability Index } (\%) = CV \times \sqrt{(1 - \bar{R}^2)} \quad \ldots\ldots\ldots \quad (5)$$

Where,

CV= Coefficient of variation in per cent.

R^2= Coefficient of determination from a time trend regression adjusted to its degrees of freedom.

RESULTS AND DISCUSSION

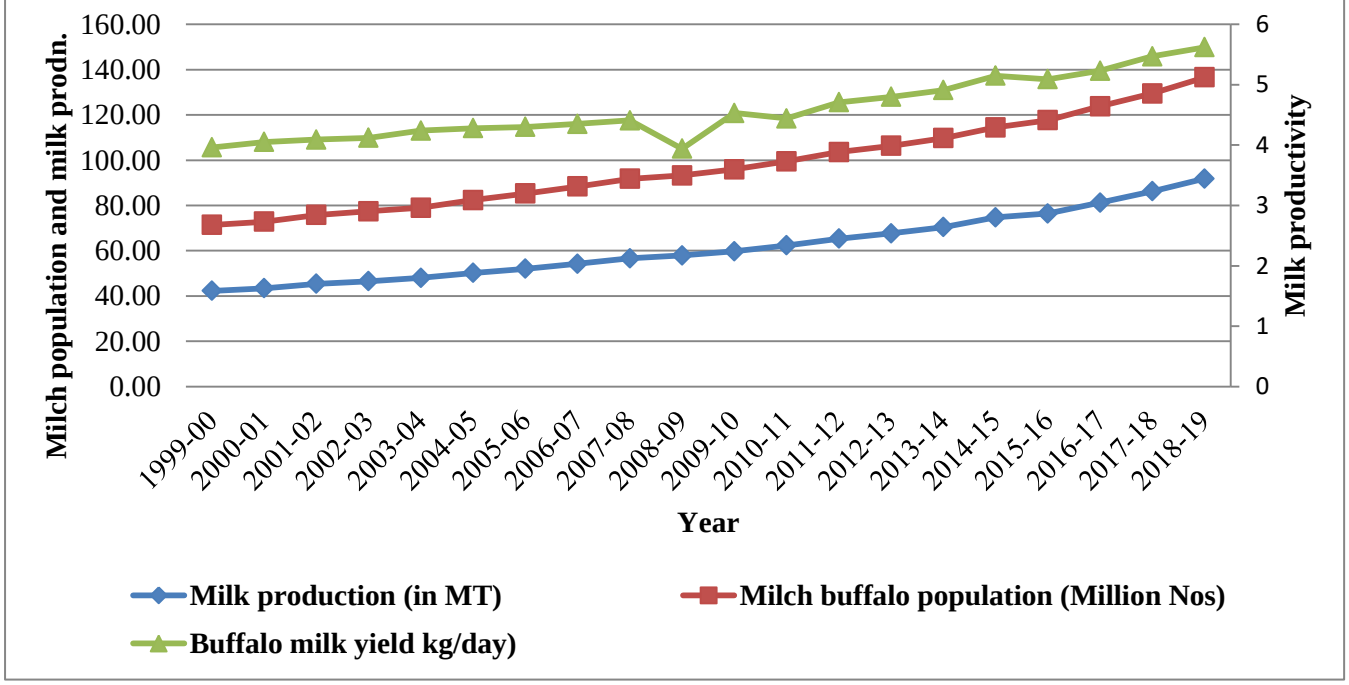
Compound annual growth rate of different states

The secondary data on milch population, milk production and productivity of buffaloes was collected from different sources viz Basic Animal Husbandry Statistics (BAHS), BAHS annual reports, livestock census and State Department of Animal Husbandry (SDAH) annual reports. The milk production from buffaloes increased over the years but the contribution of buffalo milk in total milk production decreased from 53.98 per cent in 1999-00 to 48.90 per cent in 2018-19. But still the buffalo milk is the future of the Indian dairy industry due their fat rich, low cholesterol milk constituents. The CAGR of buffalo milk production increased at the rate of 4.04 per cent per year since 1999-00 from 42.27 MT in 1999-00 to 91.82 MT in 2018-19 (Figure 1). The increase in milk production may be due to the increase in population of milch buffaloes and milk productivity. The milch buffalo population registered a growth rate of 2.27 per cent per annum with 45 million headcounts in 2018-19 from 29.16 million headcounts

in 1999-00. Whereas, milk productivity of buffaloes increased from 3.96 kg per day to 5.62 kg per day with the growth rate of 1.74 per cent per annum over the same period. The contribution of milch buffalo growth rate was significantly higher than the growth rate of milk productivity. In the year 2008-09, there was dip in the milk productivity of the buffaloes which may be attributed to more number of dry animals than buffaloes in milk. High proportion of nondescript breeds as well less coverage of Artificial Inseminations (AIs) is the other major constraints for not achieving full potential of buffaloes.

At present, the A.I coverage in buffaloes is only 30 per cent and remaining 70 per cent are either left unbred or bred with unknown genetic merit germplasm. The low AI coverage leads to low conception rate in the buffaloes. The overall conception rate in the buffaloes was 25.52 per cent as against the 34.53 per cent in cows (Reference). Among the buffaloes, the conception rate of the non-descript were lowest i.e. 22.24 per cent, this may be due to number of reasons like reproductive disorders, feeding deficiencies etc. The lack of availability of superior germplasm and lack of awareness among farmers about benefits of the AI are the major reason for low rate of the conception in the buffaloes. Therefore, there is need to increase the AI coverage through superior quality frozen semen at farmers door step for the up-gradation of non-descript buffaloes and to enhance the milk productivity for the sustainable and profitable milk production.

Fig. 1 Milch population, milk production and productivity of buffaloes (1999-00 to 2018-19)



Growth and instability matrix for milch population, milk production and productivity of buffaloes

For further analysis of this secondary data, the growth rate and instability index was estimated for milch population, milk production and productivity of buffaloes from 1999-00 to 2018-19 and the results are shown in shown in growth-instability matrix (Table 2). The selected states were classified into four different quadrants such as positive growth rate-low instability, positive growth rate-high instability, negative growth rate-low instability and negative growth rate-high instability index of milch population, milk production and productivity of the buffaloes based on CAGR and Cuddy Della Valle Index.

Milch population

In the quadrants of milch buffalo population, states namely; Bihar, Gujarat, Haryana, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan and Telangana were shown the positive growth trend with low instability index. It indicates that the milch buffalo population consistently increased over the period and this is called zone of comfort for the growth of the milch buffalo population. Some of the states have superior breeds like Muarrah in Haryana, Nili-Ravi in Punjab and Mehasana, Surti, Jaffrabadi in Gujarat; farmers of these states are more interested in buffalo husbandry mainly due to high yield of these breeds. On other hand states like Andhra Pradesh, Jharkhand and Uttarkhand registered positive growth trend in milch buffalo population with high instability index. However, in these states milch population needs to be stabilized by following different strategies like increasing the number of AIs, addressing the reproductive problems, better nutrition etc.

Assam, Chhattisgarh, Himachal Pradesh, Uttar Pradesh and West Bengal registered negative growth and low instability index. Since these may be less emphasise on maintaining milch buffaloes as they get good price for their dry buffaloes. Uttar Pradesh and West Bengal export buffalo meat, this may cause the decline in the milch. In states like Kerala, Delhi, Goa, Odisha and Tamil Nadu the growth trends were found to be negative with high instability index. Mainly in Kerala and Tamil Nadu the farmers are shifting from buffalo farming to the crossbred cow farming. Also, there is huge market for buffalo meet due to ban on cow slaughter. Increasing urbanisation and lack of feed and fodder could be another reason for decline in buffalo population.

Milk productivity

Under milk productivity growth and instability matrix, twelve states namely Assam, Bihar, Gujarat, Haryana, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Telangana, Uttar Pradesh and Uttarkhand registered positive growth with low instability index. These states contribute significantly to the milk production. Moreover, number of superior germpalsm in Haryana and Punjab with respect to breeds like Murrah and Nili-Ravi is much more, which led to constant increase in milk productivity. Especially in Haryana where Integrated Murrah Development Scheme (IMDS) was implemented to conserve and upgrade the superior germplasm to enhance the milk productivity of the buffaloes. States like Madhya Pradesh, Maharashtra,

Uttarkhand, Bihar, Rajasthan and Telangana while importing superior quality frozen semen which will be used for the breeding purpose. Assam and Uttar Pradesh are the states where low yielding buffaloes are used for the meat purpose. Therefore, the milk productivity in these states is increasing due to decreasing population.

The positive growth with high instability was observed in states Andhra Pradesh, Chhattisgarh, Goa, Himachal Pradesh and Karnataka. The main reason for the increase in milk productivity may be due to breeding policy of the state to use superior quality germplasm for AI. In the year 2009-10, Government of Andhra Pradesh purchased approximately 1.50 lakh Murrah buffaloes (both male and female) from Haryana to improve milk productivity in the state. Thus, there is a need to have proper breeding strategies for increasing the milk production.

The negative growth and high instability in milk productivity quadrant, the only state is Tamil Nadu. Whereas states like Delhi, Jharkhand, Kerala and West Bengal have registered negative growth trend with high instability index. This could be due to change in the bovine composition i.e. from buffalo husbandry to crossbred cow rearing.

Milk production

With regard to milk production growth and instability matrix, twelve states namely Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Madhya Pradesh, Maharashtra, Odisha, Punjab, Telangana and Uttar Pradesh registered positive growth and low instability index. These states produce maximum milk in the country consistently. This could happen mainly due to positive growth trend in milk productivity with low instability index except in Himachal Pradesh. These states need to be encouraged to maintain consistence performance for continuous milk supply to meet the emerging demand for the milk and milk products. On other hand, in states like Andhra Pradesh, Jharkhand, Karnataka, Rajasthan and Uttarkhand showed that positive growth trend with high instability. Instability in milk production needs to be addressed through awareness of farmers about high yielding buffaloes.

In the states of West Bengal and Goa the buffalo milk production has negative growth rate with low instability. In West Bengal this is due to decrease in the population of milch buffaloes. The remaining states Chhattisgarh, Delhi, Kerala and Tamil Nadu fell in the quadrant of negative trend in milk productivity with high instability index. In Kerala, Chhattisgarh and Tamil Nadu the decline in buffalo milk production may be due to decrease in milch buffalo population as well as decline in milk productivity of the buffaloes. In Delhi due to urbanization farmers shifting from buffalo husbandry to other remunerative enterprise.

Table 2: Growth and instability matrix for milch population, milk production and productivity of the buffaloes

Milch buffalo population (Instability index distinction: 6.05)		
CAGR	**Low**	**High**
Positive	(10) Bihar, Gujarat, Haryana, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan and Telangana	(03) Andhra Pradesh, Jharkhand and Uttarkhand
Negative	(05) Assam, Chhattisgarh, Himachal Pradesh, Uttar Pradesh and West Bengal	(04) Delhi, Goa, Kerala, Odisha and Tamil Nadu
Milk production (Instability index distinction: 5.26)		
Positive	(12) Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Madhya Pradesh, Maharashtra, Odisha, Punjab, Telangana and Uttar Pradesh	(05) Andhra Pradesh, Jharkhand, Karnataka, Rajasthan and Uttarkhand
Negative	(02) West Bengal and Goa,	(04) Chhattisgarh, Delhi, Kerala and Tamil Nadu
Milk productivity (Instability index distinction: 3.87)		
Positive	(12) Assam, Bihar, Gujarat, Haryana, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Telangana, Uttar Pradesh and Uttarkhand	(05) Andhra Pradesh, Chhattisgarh, Goa, Himachal Pradesh and Karnataka
Negative	(01) Tamil Nadu	(04) Delhi, Jharkhand, Kerala and West Bengal

Scenarios to enhance sustainable milk productivity based on existing situation

The possible approach to attain sustainable milk production for different states based on existing situation is shown in the table 3. The state positioned in different quadrants have to focus on their respective scenarios in milch buffalo population, milk production and milk productivity. The states falling in the quadrant of the positive trend

in milk productivity with low instability index should be encouraged to continue the existing breeding policies and be given preference to upgrade the non-descript milch buffalo in the state through superior germplasm. States with positive growth rate and high instability index needs to focus on the stabilizing the milk productivity by increasing the AI coverage area with superior germplasm for the inseminations at famers door step. The states with negative trend in milk productivity with low & high instability index needs to be given more attention by closely monitoring the breeding policies for implementation. In these states farmers may be sensitized about heat symptoms, benefits of AI and balanced feeding to increase the conception rate. The states with low milk productive non-descript breed needs to be upgrade with superior germplasm for the sustainable and profitable milk production.

Table 3: Scenarios to enhance sustainable milk productivity based on existing situation

Growth	**Instabilit y**	
	Low	**High**
Positive	Need to be given preference for upgrade the non-descript milch buffalo milk productivity.	Need to focus on stabilizing and improving the milk productivity.
Negative	Need to focus on sustaining the milk production.	Need to focus on stabilizing the milk productivity.

Source: *Sharma, et al. (2015) and Balaganesh et al. (2019)*

Classification of states

In the table 3, states were classified into four categories such as High Milch Population & High Milk Productivity (HPHP), High Milch Population with Low Milk Productivity (HPLP), Low Milch Population with High Milk Productivity (LPHP) and Low Milch Population with Low Milk Productivity (LPLP). The states categorised under HPHP namely Andhra Pradesh, Gujarat, Haryana, Punjab and Rajasthan contributes significantly to the milk production with milch population of 15.42 million headcounts. The milk productivity is highest (5.73 kg per day) in this category. For this category, productivity range is from 4.46 kg/day (Andhra Pradesh) to 7.76 kg/day (Punjab). The states such as Madhya Pradesh, Maharashtra, Karnataka, Bihar and Uttar Pradesh classified as HPLP has more potential to produce more milk if the non-descript buffaloes are bred with superior germplasm through AI. Under LPHP the Jharkhand, Kerala, West Bengal, Delhi and Telangana have low milch population with high milk productivity. Efforts may be made to popularise buffalo husbandry through different types of incentives. However, there are 7 states namely Assam, Chhattisgarh, Goa, Himachal Pradesh, Odisha, Uttarkhand and Tamil Nadu which fall under LPLP category with milch population of 1.94 million headcounts and average milk productivity of 3.44 kg/day. Productivity range is from 2.40 kg/day (Assam) to 4.11 kg/day (Tamil Nadu). Hence,

both milk population and productivity needs to be improved by adopting different types of measures like superior germplasm for AI, balanced feeding and different improved buffalo husbandry practices.

Table 4: Classification of states based milch population and milk productivity of the buffaloes

Particulars	**High milch population and higher milk productivity**	**High milch population and low milk productivity**	**Low milch population and higher milk productivity**	**Low milch population and low milk productivity**
Number of states	5	5	5	7
Milch population (Millions)	15.42	17.41	0.97	1.94
Average productivity (Kg/day)	5.73	3.72	5.15	3.44
Productivity range	4.46 (Andhra Pradesh) to 7.76 (Punjab)	2.76 (Karnataka) to 4.33 (Uttar Pradesh)	4.35 (Jharkhand) to 6.10 (Delhi)	2.40 (Assam) to 4.11 (Tamil Nadu)
Name of the states	1. Andhra Pradesh 2. Gujarat 3. Haryana 4. Punjab 5. Rajasthan	1. Madhya Pradesh 2. Maharashtra 3. Karnataka 4. Bihar 5. Uttar Pradesh	1. Jharkhand 2. Kerala 3. West Bengal 4. Delhi 5. Telangana	1. Assam 2. Chhattisgarh 3. Goa 4. Himachal Pradesh 5. Odisha 6. Uttarkhand 7. Tamil Nadu

CONCLUSION

For the study, secondary data was collected from various sources. The CAGR for the milch population, milk production and productivity of the buffaloes has shown increasing trends over the years. The higher milk production was due to population of milch buffaloes. The states having negative growth rate and high instability index for milch population and milk productivity in growth-instability matrix needs to stabilize their milk productivity for the better and continuous milk production. The states classified under Low Milch Population and Low Milk Productivity (LPLP) may be given

more attention to minimize the decline in the milch buffalo population as well as improve the milk productivity of the non-descript buffaloes for sustainable milk production. Overall, the states with higher population of lactating buffaloes and productivity needs to be sustained. Genetic potential of the non-descript buffaloes may be enhanced through artificial insemination of superior germplasm.

REFERENCES

Balaganesh, G., Makarabbi, G. and Sendhil, R. (2019). Tracking the Performance of Wheat Production in Uttar Pradesh. Indian Journal of Economics and Development. **15(2)**: 216-224. DOI:10.5958/2322-0430.2019.00026.X

Cuddy, J. D. A., and Valle, P. A. D. (1978). Measuring the instability of time series data. Oxford Bulletin of Economics and Statistics. **40(1)**, 79-85.

FAO. 2000. Water buffalo: An asset undervalued. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand. http://empaeg.com/UserFiles/File53242. pdf. (Verified 12 Aug. 2014.)

GoI (Government of India). (2018). Annual report – 2018-19. Basic Animal Husbandry Statistics, Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture, New Delhi.

GoI (Government of India). (2012). 19th Livestock Census. Department of Animal Husbandry and Dairying, Ministry of Agriculture, New Delhi.

GoK (Government of Karnataka). (2018). Integrated sample report 2017-18. Department of Animal Husbandry and Veterinary Services, Bengaluru.

Sendhil, R., Singh, R., and Sharma I. (2012). Exploring the performance of wheat production in India. Journal of Wheat Research. **4(2)**: 37-44.

Siddiky, M. N. A. And Faruque, M. O. (2017). Buffaloes for dairying in South Asia: Potential, challenges and way forward. SAARC Journal of Agriculture. **15(2)**: 227-239.

Mane, B.G. Chatli, M.K. (2015). Buffalo Milk: Saviour of Farmers and Consumers for Livelihood and Providing Nutrition. Agric. Rural Dev. **2**: 5-11.

Minervino, A. H. H., Zava, Marco., Vechhio, D. and Borghese, A. (2020). Bubalus bubalis: A short story. Fronteirs in veterinary science. **7**: 1-15.

Wanapat, Metha, and Kang, Sungchhang. (2013). World buffalo production: Challenges in meat and milk production, and mitigation of methane emission. Buffalo bulletin. **32** (Special issue 1): 1-21.

Kumar, Manoj., Dahiya, S. P., Ratwan, Poonam., Kumar, Sunil, and Chitra, Anil. (2019). Status, constraints and future prospects of Murrah buffaloes in India. Indian Journal of Animal Science. **89(12)**: 1291-1302.

Sharma, I., Sendhil, R., and Chatrath, R. (2015). Regional disparity and distribution gains in wheat production. Paper published in proceedings of the 54th All India Wheat & Barley Research Workers' Meet held at Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. pp: 385-506, Gujarat. Retrieved from https://www.researchgate.net/publication/281374047