



Effectiveness of Climate Resilient Interventions on Performance of Dairy Animals in Karnal District of Haryana

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HIGHLIGHTS

- Significant differences were observed in the productive and reproductive performance of dairy animals between NICRA beneficiary and non-beneficiary villages.
- In beneficiary villages, both indigenous and crossbred cattle showed higher levels of average daily milk yield, peak yield, lactation yield, as well as lactation length.
- In beneficiary villages, buffalo also showed increased average daily milk yield, peak yield, lactation yield, as well as lactation length.
- Family education, experience, and participation in extension activities were important factors that affected productive and reproductive performance.

ARTICLE INFO

Keywords: Effectiveness, Climate change, Dairy animals, Performance, Intervention.

<https://doi.org/10.48165/IJEE.2025.61310>

Conflict of Interest: None

Research ethics statement(s):

Informed consent of the participants

ABSTRACT

To promote climate-resilient agriculture, the Indian Council of Agricultural Research (ICAR) initiated the National Innovations in Climate Resilient Agriculture (NICRA) project. In light of this context, the current study was undertaken in 2022 to assess the effectiveness of technological interventions on the reproductive and productive performance of dairy animals. This study was conducted in the Karnal district of Haryana, which was selected purposively. A sample of 120 respondents was selected, comprising 60 individuals from three NICRA beneficiary villages and 60 from three non-beneficiary villages. Using the Mann-Whitney U test, a significant difference was observed in the productive and reproductive performance of dairy animals. In the beneficiary villages, indigenous cows showed an improvement in both average daily milk yield and lactation yield. Among crossbred cows, there was a positive increase in average daily milk yield, peak yield, lactation yield, and lactation length. Similarly, buffaloes owned by beneficiary farmers exhibited enhanced peak yield, daily milk production, and overall lactation yield. Correlation of socio-economic variables like family education, experience, and participation in extension activities showed a positive correlation towards the productive parameters and a negative correlation towards inefficiencies of reproductive parameters, indicating their enhancing influence on dairy animals.

INTRODUCTION

The foundation of the Indian economy is the agriculture sector, which accounted for 18 per cent of the country's GVA in the

financial year 2024-2025 (PIB, 2025). India is the world's largest producer of milk, demonstrating its dominance in the production of agricultural goods (Economic Division, 2024). In the Indian economy, the livestock industry is a significant subsector of

agriculture. The amount of milk produced in 2022–2023 and 2023–2024 was 230.6 million tonnes and 239.3 million tonnes, respectively, representing a 3.77 per cent annual rise. Approximately 471 grams of milk per day was available per person in 2023–24 (NDDB, 2025). The livestock sector's contribution to the Gross Value Added (GVA) is increasing, highlighting the role of dairying as a driver of social change in India. Projections reveal that India's milk production will increase from 239.1 million tons in 2024 to 321.4 million tons in 2033 (Jirli et al., 2025). This decentralized and small-scale dairy farming model contrasts sharply with developed nations, where specialized dairy farming is more prevalent (Basic Animal Husbandry Statistics, 2020).

Haryana ranks second in the country for per capita milk availability (Basic Animal Husbandry Statistics, 2020). Climate change has deteriorating impacts on livestock production both directly and indirectly. There are various prominent direct consequences of climate change on dairy cattle (Malarkkannan & Kathirchelvan, 2017). It has been projected project the losses to milk production on account of heat stress was 377 thousand tonnes, which translates to a loss of 12.44 billion Indian rupees (Choudhary & Sirohi, 2022). Thus, there is an urgent requirement to bring the focus to climate-resilient production techniques in the dairy sector. The primary objective of climate resilience efforts is to address climate variability by enabling systems to absorb stress, maintain functionality under adverse climatic conditions, and adapt in ways that enhance long-term sustainability. A large share of farmers believe climate change to be anthropogenic as well as naturogenic (Kumar & Saxena, 2024), thus implying they have a basic understanding of the scenario. So, there is a need to reduce the impact of climatic stress, for which it is crucial to adopt effective mitigation technologies, such as developing climate-resistant crop and livestock breeds. In support of climate-resilient agriculture, the Indian Council of Agricultural Research (ICAR) launched the National Innovations in Climate Resilient Agriculture (NICRA) project in 2011. NICRA provides inputs and services to rural areas. In service, animal health camps, kisan gosthi, scientist-farmers session, exposure visits, and advisory services are provided. Additionally, mineral mixture, bedding material, endo and ecto parasite control measures, and dairy animal health kits are provided to farmers in form of inputs. This initiative aims to enhance the adaptability of Indian agriculture including livestock to climate change.

METHODOLOGY

The present study was conducted in the specifically selected Karnal district of Haryana with an objective to assess the effectiveness of technological intervention on performance of dairy animals. This selection was based on the fact that NICRA project was implemented in seven villages of Karnal district. As part of the sampling design, three of these villages were purposively selected for this study. Three categories of milch animals-indigenous cows, crossbred cows, and buffaloes were considered. The average milk yield of each animal during the lactation period was recorded for each respondent. To assess the productive performance and reproductive performance of dairy animals, specific criteria were used as indicated:

Parameters under productive performance were as follows:

Peak yield (PY): It was measured as the highest milk produced by the milch animal in its lactation length, expressed in litres.

Average daily milk yield (ADMY): It referred to the average milk yield of an animal during lactation. This was measured in litres/day by using the following formula:

$$\text{Average milk yield (lit/day)} = \frac{\text{Lactation yield}}{\text{Lactation length}}$$

Lactation length: It referred to the number of days the cow or buffalo remained in milk from the date of calving to the date of drying, expressed in days or months.

Lactation length = Total days a dairy animal remained in milk

Lactation milk yield: The average total quantity of milk provided by an animal in its lactation period expressed in litres and calculated by the following formula:

$$\text{Lactation milk yield} = \text{ADMY} \times \text{Total Lactation Length}$$

Parameters under reproductive performance were as follows:

Age at first calving: The actual age of the animal at the time of first calving, expressed in months.

Service per conception: Average number of insemination or natural service required by an animal to become pregnant.

Calving interval: The period between two successive calvings i.e., the period between the calving of the first calf to the calving of immediate next calf and was expressed in days.

A pre-tested structured interview schedule was used to collect data and ensure consistency in data collection. The data were collected between February 2022 and May 2022. 60 farmers were randomly selected from the beneficiary villages and 60 non-beneficiary farmers were selected from non-beneficiary villages randomly, where selection criteria was the farmers should have minimum five dairy animals and at least five years' experience in dairying. So a total of 120 respondents were the main contributors of primary information for investigation. Extent of significant difference of control group and treatment group were assessed using Mann-Whitney U test, and to understand the association of socio-economic variables with various performance parameters, correlation coefficient was used.

RESULTS

The average number of buffaloes, indigenous and crossbred cattle present in both beneficiary and non-beneficiary households are indicated in Table 1, expressed in standard animal unit. All the parameters of productive and reproductive performance were measured as average value taken from each household as indicated

Table 1. Average number of dairy animals present in households

Average number of dairy animals (in SAU)	Beneficiary farmers (n=60)	Non beneficiary farmers (n=60)
Indigenous cattle	1.28	1.58
Crossbred cattle	4.42	3.71
Buffaloes	2.61	3.83

by the respondents. Thus, unit of analysis is household level and sample size is same for all the parameters and all types of dairy animals.

Productive performance

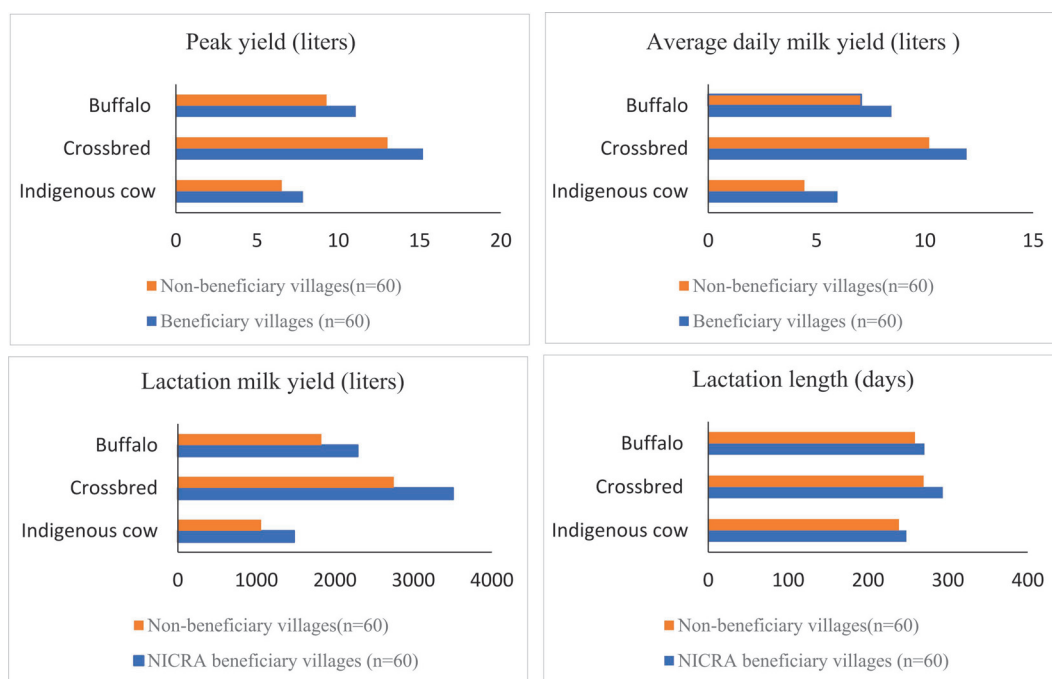
The data in Table 2 and Figure 1 shows that the average of peak milk yield of indigenous cows in beneficiary villages was approximately 8 litres, compared to 6.52 litres in non-beneficiary villages. For crossbred cows, the peak yield was 15.21 litres in beneficiary areas, while it was slightly lower at 13.02 litres in non-beneficiary villages. In the case of buffaloes, the peak yield reached 11.07 litres in beneficiary villages, whereas it was about 9 litres in non-beneficiary areas. The differences in peak milk yield for indigenous cows, crossbred cows, and buffaloes between the two types of villages were found to be statistically significant at

$p < 0.001$. The average of Average Daily Milk Yield (ADMY) of indigenous cows in beneficiary villages was around 6 litres, and in non-beneficiary villages, it was only 4.44 litres. In crossbred, the yield was 11.93 litres, and in non-beneficiary villages, it was about 10.20 litres, whereas buffaloes showed a yield of 8.46 litres in beneficiary villages, while the same was around 7.06 litres in non-beneficiary villages. Mann-Whitney U test showed a significant difference in ADMY of all three dairy animals of beneficiary and non-beneficiary farmers. It is clear from the data in Table 2 that the average Lactation Milk Yield (LMY) of indigenous cows in beneficiary villages was approximately 1480 litres, compared to about 1060 litres in non-beneficiary villages. For crossbred cows, the LMY was around 3500 litres in beneficiary areas, while it was roughly 2750 litres in non-beneficiary villages. In the case of buffaloes, the average yield was nearly 2290.37 litres in beneficiary

Table 2. Productive performance of dairy animals

Productive traits	NICRA beneficiary villages (n=60)	Non-beneficiary villages (n=60)	Mann-Whitney test		
			U statistics	Z value	P value
Peak yield (liters)					
Indigenous cow	7.82 $\pm$ 0.11	6.52 $\pm$ 0.11	474.000	-6.139	0.000
Crossbred	15.21 $\pm$ 0.19	13.02 $\pm$ 0.15	88.000	-8.555	0.000
Buffalo	11.07 $\pm$ 0.13	9.27 $\pm$ 0.17	270.000	-7.522	0.000
Average daily milk yield (liters)					
Indigenous cow	5.97 $\pm$ 0.098	4.44 $\pm$ 0.9	512.000	-5.889	0.000
Crossbred	11.93 $\pm$ 0.16	10.20 $\pm$ 0.14	50.000	-8.778	0.000
Buffalo	8.46 $\pm$ 0.06	7.06 $\pm$ 0.11	532.000	-5.993	0.000
Lactation milk yield (liters)					
Indigenous cow	1481.21 $\pm$ 14.44	1059.96 $\pm$ 12.70	222.000	-7.602	0.000
Crossbred	3504.19 $\pm$ 46.60	2750.32 $\pm$ 37.86	224.000	-9.048	0.000
Buffalo	2290.37 $\pm$ 14.82	1827.90 $\pm$ 25.77	231.000	-7.671	0.000
Lactation length (days)					
Indigenous cow	248.11 $\pm$ 3.23	238.73 $\pm$ 3.48	591.500	-5.298	0.000
Crossbred	293.73 $\pm$ 1.43	269.64 $\pm$ 1.80	239.500	-7.653	0.000
Buffalo	270.73 $\pm$ 1.84	258.91 $\pm$ 1.78	265.000	-7.498	0.000

Figure 1. Productive performance of dairy animals in NICRA and non-NICRA villages



villages and 1827.90 litres in non-beneficiary ones. In case of the average lactation length of indigenous cows in beneficiary villages, it was approximately 248 days compared to around 238 days in non-beneficiary villages. For crossbred cows, the lactation period was about 293 days in beneficiary areas, whereas it was roughly 270 days in non-beneficiary villages. In the case of buffaloes, the lactation length averaged around 270 days in beneficiary villages and about 259 days in non-beneficiary ones. The difference was significant in the lactation lengths of dairy animals between the beneficiary and non-beneficiary villages.

Reproductive performance

A glance at Table 3 and Figure 2, which illustrates the age of dairy animals at first calving, shows that indigenous cows in beneficiary villages calved for the first time at an average age of 35.89 months, compared to 37.89 months in non-beneficiary villages. For crossbred cows, the average age at first calving was

about 28 months in beneficiary villages and 30.36 months in non-beneficiary villages. In the case of buffaloes, the age at first calving was approximately 39.15 months in beneficiary villages, while it was 42.79 months in non-beneficiary ones. The difference in age at first calving relating the two groups was found to be statistically significant.

Table 3 also reveals that the average number of services per conception for indigenous cows, crossbred cows, and buffaloes in beneficiary villages was 1.19, 1.56, and 1.53, respectively. In contrast, the corresponding figures in non-beneficiary villages were significantly higher: 2.33 for indigenous cows, 3.05 for crossbred cows, and 2.30 for buffaloes. This indicates a significant difference in the number of services needed per conception between beneficiary and non-beneficiary villages. Regarding results for average calving interval presented in Table 3, in beneficiary villages, it was 388.88, 382.18 and 397.73 days for indigenous cows, crossbred and buffaloes, respectively. While in non-beneficiary

Table 3. Reproductive performance of dairy animals

Reproductive traits	NICRA beneficiary villages (n=60)	Non-beneficiary villages (n=60)	Mann-Whitney test		
			U statistics	Z value	P value
Age at first calving in months					
Indigenous cow	35.89 ±0.15	37.41 ±0.39	101.500	-8.450	0.000
Crossbred	28.25 ±0.09	30.36 ±0.28	5.000	-9.158	0.000
Buffalo	39.15 ±0.19	42.79 ±0.34	507.000	-6.186	0.000
Number of services per conception					
Indigenous cow	1.19 ±0.05)	2.33(±0.06)	185.000	-8.483	0.000
Crossbreed	1.56(±0.04)	3.05(±0.08)	406.500	-4.143	0.000
Buffalo	1.53(±0.07)	2.30(±0.10)	920.000	-3.568	0.000
Calving interval in days					
Indigenous cow	388.58(±3.57)	427.82(±1.65)	244.000	-7.514	0.000
Crossbreed	382.18(±2.03)	417.55(±1.74)	174.500	-8.044	0.000
Buffalo	397.73(±1.39)	432.64(±1.83)	422.000	-7.256	0.000

Figure 2. Reproductive performance of dairy animals in NICRA and non-NICRA villages

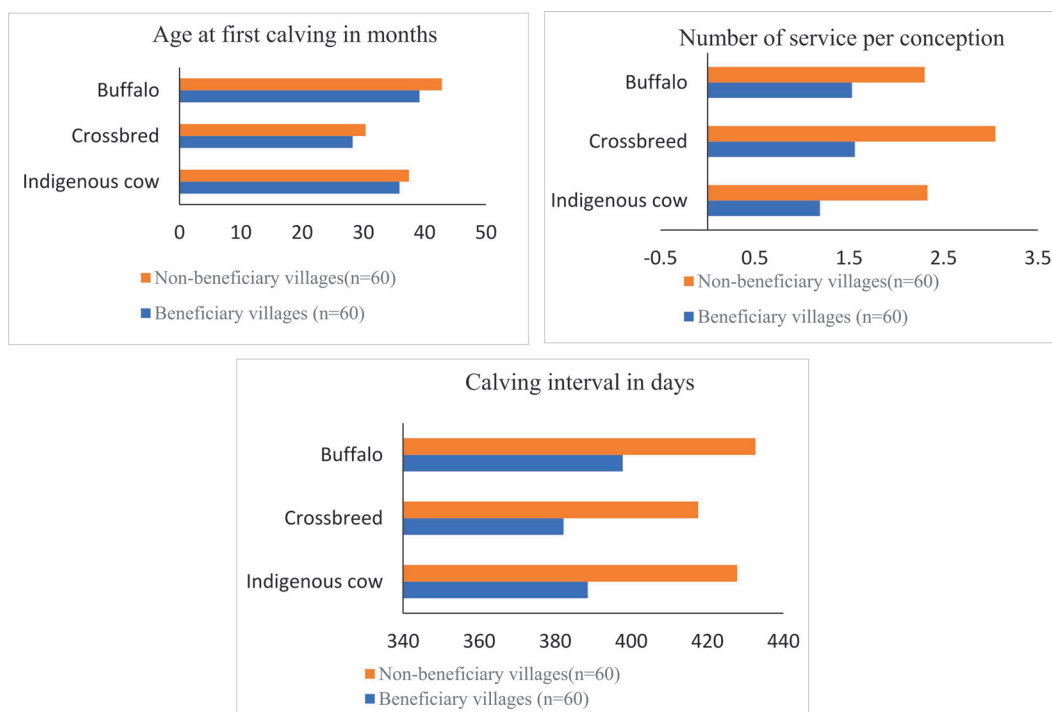


Table 4. Relation between performance of dairy animals and socio-economic variables

Association of socio-economic variables with performance parameters expressed in terms of correlation coefficient

	Peak yield	Average daily milk yield	Lactation yield (litres)	Lactation length (days)	Age at first calving in months	No. of service per conception	Calving interval in days
Education	0.048	0.024	0.028	0.056	0.011	-0.020	-0.127
Experience	0.177	.184*	.200*	0.165	-0.271**	-0.190*	-0.201*
Family size	0.105	0.087	0.093	0.080	-0.116	-0.054	-0.034
Income(lacs)	0.062	0.062	0.053	0.077	-0.049	-0.056	-0.062
Family educational status	0.383**	0.372**	0.348**	0.284**	-0.375**	-0.393**	-0.259**
Operational landholding	0.027	0.006	0.015	0.034	-0.046	-0.063	0.004
Herd Size	0.046	0.115	0.109	0.045	-0.078	0.032	0.073
Extension contact of household	0.248**	0.286**	0.263**	0.200*	-0.234*	-0.222*	-0.136
Mass media/ social exposure of the household	0.237**	0.257**	0.237**	0.217*	-0.222*	-0.231*	-0.203*
Participation in extension activities	0.327**	0.335**	0.318**	0.267**	-0.280**	-0.307**	-0.243**

*. Correlation is significant at the 0.05 level (2-tailed); **. Correlation is significant at the 0.01 level (2-tailed)

villages, for indigenous cows, crossbred and buffaloes, the intervals were 427.82, 417.55 and 432.64 days, respectively. Results showed that NICRA beneficiaries' dairy animals had a lower calving interval when compared to animals kept by non-beneficiaries. Hence, a significant difference was seen between beneficiary and non-beneficiary villages.

To understand the effect of socio-economic variables on the productive and reproductive performance of animals, a correlation analysis was done. Table 4 reveals that family educational status was strongly associated (significant at 0.01) with all the parameters of productive performance with positive outcomes and negatively correlated with the parameters like age at first calving, number of services per conception and calving interval in days. Experience was positively associated with average daily milk yield and lactation yield while negatively correlated with the age at first calving, number of services per conception and calving interval in days. extension contact, media exposure, and participation in extension activities all show strong positive associations with productive performance and negative associations with reproductive parameters.

DISCUSSION

In the productive performance indicators, indigenous cows, crossbred cows, and buffaloes of beneficiary farmers of NICRA had significantly higher performances than non-beneficiary farmers. The results of peak milk yield also support this finding, which is similar to the results of Meena et al., (2017) who reported that the peak yield in the villages where adoption took place was greater compared to the non-adopted villages. In case of average daily milk yield also, performance of dairy animals of beneficiary farmers were significantly higher than those of non-beneficiary farmers. The different interventions as part of NICRA could have contributed to help the beneficiaries to achieve a higher performance. It can be related with the results of Ponnusamy et al., (2019), where it has been recommended to provide a daily dose of 50 grams of mineral mixture for milch cows and buffaloes, and 20-25 grams per day for calves, which resulted in an average increase of 0.5 liters in daily milk production just after 15 days of supplementation. In a similar study by Gupta et al., (2017), it was observed that the daily

average milk yield and total milk yield was significantly higher in the treatment group compared to the control group. The average total quantity of milk produced by an animal in its lactation period, was significantly higher among farmers of beneficiary than non-beneficiary farmers. A similar study by Chakravarty et al., (2021) found that using improved fodder crop varieties along with area-specific mineral mixture supplementation was highly effective in sustaining milk production during periods of heat stress. This result aligns with the findings reported by Madke et al., (2018), where the total milk yield in the treatment group was found to be higher than that of the control group. The results suggest that the adopted practices contributed positively to enhancing milk production, indicating their potential for wider adoption to improve dairy productivity. Same benefiting results were obtained in the case of lactation length also. The lactation lengths of buffaloes, crossbred cows, and indigenous cows were notably higher among beneficiaries of NICRA, than non-beneficiaries, which is on par with the results of Meena et al., (2015), in a study conducted in Uttar Pradesh.

To assess the reproductive performance, age at first calving, service per conception and calving interval were measured among dairy animal of farmers in beneficiary and non-beneficiary villages. The age at first calving was significantly higher in the dairy animals of beneficiary than non-beneficiary farmers, which is consistent with the results of Meena et al. (2017). Service per conception in beneficiary villages was significantly higher than in non-beneficiary. Similarly, NICRA beneficiaries' dairy animals had lower calving interval than non-beneficiaries' dairy animals. All these indicators pointed to the higher and improved reproductive performances among dairy animals of NICRA beneficiaries than those of non-beneficiaries. When key reproductive traits were recorded during the experimental period, Kumar et al., (2020) reported that the first postpartum estrus after calving, service period, and number of inseminations per conception were the effective technologies to enhance the reproductive performances. In short, both productive and reproductive parameters of dairy animals are better among beneficiary than non-beneficiary villages. A similar study demonstrated that supplementing the diet of crossbred cattle with an area-specific mineral mixture led to improved productive and

reproductive performance, particularly from the first postpartum estrus through to the final trimester (Muwel et al., 2020). Here, the results indicated the effectiveness of various technologies under NICRA to overcome different climate change barriers in dairy farming. NICRA project has proved to be crucial in providing positive outcomes, including increased incomes and adaptive capacities (Sodhi et al., 2023).

While analysing the socio-economic correlates, education has been found to be correlated with both productive and reproductive parameters significantly. The presence of educated persons in the family helps the family in better comprehension and use of the scientific publications and advisory services, and a better understanding and adoption of scientific advisory services leads to overall betterment in dairy production. Also, extension contacts, media exposure, and participation in extension activities showed similar results.

CONCLUSION

The impact of climatic change interventions on productive as well as reproductive performance of dairy animals in beneficiary villages as compared to non-beneficiary is significant. Field data and related studies suggest that feeding dairy animals a localised mineral combination improved their reproductive and productive capacities, which led to shorter service times, a delay in the onset of postpartum oestrus, and an increase in milk production. Therefore, supplementing dairy cows' diets with minerals may improve their reproductive health and boost their capacity to make milk. The findings of the study will guide to check further interventions' framing with satisfactory outcomes through proper channel at the right time with right amount. The correlation analysis indicates that socioeconomic factors, particularly education, experience, and extension participation, significantly enhance dairy animals' productive performance. These factors also help reduce reproductive inefficiencies by promoting the adoption of scientific practices. Strengthening awareness and outreach can thus play a vital role in improving dairy farming outcomes

REFERENCES

- Basic Animal Husbandry Statistics. (2020). Ministry of Fisheries, Animal Husbandry & Dairying, Government of India. <https://dahd.gov.in/schemes/programmes/animal-husbandry-statistics>
- Chakravarty, R., Ponnusamy, K., & Sendhil, R. (2021). Micro-level evaluation of socio-technological interventions to address climate change-induced stresses in dairy enterprises. *Indian Journal of Dairy Science*, 74(5). doi: 10.33785/IJDS.2021.v74i05.012
- Choudhary, B. B., & Sirohi, S. (2022). Economic losses in dairy farms due to heat stress in sub-tropics: evidence from North Indian Plains. *Journal of Dairy Research*, 89(2), 141–147. <https://doi.org/10.1017/S0022029922000371>
- Economic Division. (2024). The Indian Economy: A Review. Economic Division, Department of Economic Affairs, Government of India. https://dea.gov.in/sites/default/files/The%20Indian%20Economy%20-%20A%20Review_Jan%202024.pdf
- Gupta, R., Singh, K., Sharma, M., & Kumar, M. (2017). Effect of mineral mixture feeding on the productive and reproductive performance of crossbred cattle. *International Journal of Livestock Research*, 7(12), 231–236. <http://dx.doi.org/10.5455/ijlr.20170717113236>
- Kumar, A., & Saxena, S. P. (2024). Farmers' awareness and perception about climate change in the Indo-Gangetic plain region of India. *Indian Journal of Extension Education*, 60(4), 101–106. <https://doi.org/10.48165/IJEE.2024.60418>
- Kumar, R., Rana, D. S., Kumari, R., Gupta, R., & Singh, M. (2020). Effect of area-specific mineral mixture feeding on productive and reproductive performance of dairy animals. *Journal of Entomology and Zoology Studies*, 8(4), 2407–2409. <http://dx.doi.org/10.5958/2231-6744.2020.00005.5>
- Madke, P. K., Pal, D., Prakash, S., & Kumar, A. (2018). Effect of mineral mixture feeding on milk yield in buffalo. *International Journal of Agricultural Invention*, 3(1), 84–86. <https://doi.org/10.46492/IJAI/2018.3.1.16>
- Malarkkannan, S. P., & Kathirchelvan, M. (2017). Effect of climate change and adaptation measures in dairy industry of Kerala. *International Journal of Applied and Pure Science and Agriculture*, 3(1), 139–146.
- Meena, B. S., Sankhala, G., Meena, H. R., & Maji, S. (2017). Performance of dairy animals in rural Haryana: A comparative field analysis. *International Journal of Livestock Research*, 7(10), 113–121. <http://dx.doi.org/10.5455/ijlr.20170716125427>
- Meena, B. S., Verma, H. C., Meena, H. R., Singh, A., & Meena, D. K. (2015). Field level study on productive and reproductive parameters of dairy animals in Uttar Pradesh, India. *Indian Journal of Animal Research*, 49(1), 118–122. <http://dx.doi.org/10.5958/0976-0555.2015.00024.2>
- Muwel, N., Mondal, M., Choudhary, S., Karunakaran, M., & Ghosh, M. K. (2020). Effect of area-specific mineral mixture feeding on reproductive performance and milk yield in crossbred cattle reared under intensive farm condition. *Journal of Animal Research*, 10(5), 771–775. <http://dx.doi.org/10.30954/2277-940X.05.2020.14>
- NDDB. (2025). Milk Production in India. Retrieved from <https://www.nddb.coop/information/stats/milkprodindia> (Accessed on April 10, 2025).
- Pachava, V., Jirli, B., Basavaraj, M. S., Kumar, R. S., & Golla, S. K. (2025). Forecasting milk production in India: Strategic insights for policymakers and farmers. *Indian Journal of Extension Education*, 61(2), 14–18. <https://doi.org/10.48165/IJEE.2025.61203>
- Ponnusamy, K., Chakravarty, R., & Singh, S. (2019). Extension interventions in coping of farmers against effect of climate change in dairy farming. *Indian Journal of Dairy Science*, 72(4), 430–436. <https://doi.org/10.33785/IJDS.2019.v72i04.013>
- Press Information Bureau. (2025). Summary of economic survey 2024–25. Ministry of Finance, Government of India. Retrieved from <https://pib.gov.in/PressReleasePage.aspx?PRID=2090875> (Accessed on April 10, 2025).
- Singh, N. M., Tripathi, A. K., Saikia, R., Medhi, K., Gogoi, S. H., Gogoi, P., & Hojai, N. (2020). Effect of area specific mineral mixture supplementation on milk yield and reproductive traits of crossbred dairy cattle under sub-tropical region of north eastern India. *International Journal of Chemical Studies*, 8(6), 2239–2243. <https://doi.org/10.22271/chemi.2020.v8.i6af.11108>
- Sodhi, G. P. S., Dhillon, G. S., Ahuja, S., Kaur, T., Murai, A. S., Singh, R., & Kaur, S. (2023). Adoption behaviour of climate-resilient agricultural practices in Punjab under NICRA Project. *Indian Journal of Extension Education*, 59(2), 46–50. <http://doi.org/10.48165/IJEE.2023.59210>