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# Structural Transformation in Dairy Sector of India§

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**Abstract**

The paper has looked into the process of structural transformation of India's dairy sector. During the past two decades, the sector grew at the rate of 4 per cent per year, making milk as the single largest agricultural commodity in the country. The growth in dairying has primarily been driven by yield improvement. A conspicuous shift has been observed in the composition of dairy herd from traditional to crossbred cows and buffaloes, and this led to improvements in milk-yield. Genetic enhancement, better management of stock and farmers' improved access to milk markets have driven the process of transformation. Nevertheless, the status of dairy infrastructure and the delivery of veterinary services in the country are still poor and concerted efforts are required to bring about further transformation.

**Key words:** Milk production, dairy sector, sources of growth, structural transformation

**JEL Classification:** Q13, Q18, O13



## Introduction

Dairying plays an important role in strengthening rural economy of India. It is perceived to be an effective instrument for bringing socio-economic transformation. It contributes more than one-fifth to the agricultural value of output and provides employment to about 21 million people, the majority of whom are resource-poor (Kumar *et al.,* 2010). Dairying in India has come a long way, from being written off as a basket case to the largest milk producer in the world, with production crossing 121 million tonnes in 2010-11 (BAHS, 2012). Milk production has increased tremendously despite the fact that 70 per cent of its producers are small landholders and landless households.

The dairy sector has undergone a significant structural change over time. Several interesting patterns are unfolding along the milk value chain, the noteworthy being: changes in composition of dairy species in favour of crossbred cows, expanding network of dairy cooperatives and increased participation of private sector in milk collection and processing (Rajendran and Mohanty, 2004; Singh and Datta, 2010; Kumar *et al.,* 2010; Birthal and Negi, 2012). These changes contributed significantly to the growth of India's dairy sector, and the process is popularly known as 'White Revolution'. Yet, there are several concerns that take away the shine from the glorious achievements. Milk yield is quite low, despite a shift in herd composition in favour of high-yielding crossbred cows. The low milk yield is due to poor genetic make-up, shortage of feed and fodder, inadequate animal health care, etc. (FAO, 2003; Chand and Raju, 2008).

Nonetheless, there is lack of a cause and effect relationship to better understand the factors constraining improvements in milk yield. Identification of the specific factors will help in developing strategic interventions for raising milk yield and ensuring

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sustainable growth of the dairy sector. Under this background, this paper looks into the process of structural transformation of dairy sector in terms of trends in milk production and sources of growth therein.

## Data and Methodology

### Data

The study is based on the data compiled from various published sources. Data on milk production, dairy animals and their yields, veterinary institutions, dairy cooperatives and milk processing were compiled from the *Basic Animal Husbandry Statistics,* published by the Department of Animal Husbandry, Dairying and Fisheries of the Ministry of Agriculture, Government of India. Data on the number of operational landholdings, irrigation and cultivated area under fodder crops were compiled from the *Agricultural Statistics at a Glance,* published by the Directorate of Economics and Statistics, Ministry of Agriculture. Data on the number of veterinarians in the country were extracted from the website (http://www.oie.int/animal-health-in-the-world) of The World Organization for Animal Health (OIE).



### Methodology

Besides descriptive statistics and trends, decomposition analysis was carried out to assess the relative contribution of animal population and yield to the growth of milk production.

$$\Delta Q = \Delta P.Y^{o} + \Delta Y.P^{o} + \Delta P.\Delta Y$$

where, $\Delta Q = Q_t - Q_0$, $\Delta P = P_t - P_0$, and $\Delta Y = Y_t - Y_0$

Here, $\Delta P.Y^0$ represents the population effect, $\Delta Y.P^0$ represents the yield effect, and $\Delta P.\Delta Y$ represents the interaction effect. $Q$, $Y$ and $P$ represent milk production, milk yield and population, respectively; subscripts $o$ and $t$ represents the base year and terminal year, respectively.

Irrespective of whether the past growth has been driven by animal numbers or yield, the enhancement in milk yield is critical to ensure a sustainable growth in milk production in the long-run. To identify the major determinants and their causal relationship with milk yield, regression analysis was carried out. A panel data of 23 states for the period 1992-93 to 2010-11 was used for this purpose. The average milk yield (YLD) measured in litres/animal/day in the selected states was taken as dependent variable in the regression. The explanatory variables included in the analysis were: share of crossbred in milch animal stock (CRBRED %), share of buffalo in milch animal stock (BUF %), herd size in terms of number of bovine animals per rural household (HSIZE), area under irrigation (IRR %), number of dairy co-operative societies per thousand bovine units (COOP) and number of veterinary institutions per thousand bovine units (VET). Means and standard deviations of the explanatory variables are provided in Annexure I.

Among the selected explanatory variables, the ratio of crossbreds in the total female milch bovines was taken to represent the technological change in the dairy sector. Breed improvement in cattle has been an important component of India's dairy development policy, and share of crossbreds in total female cattle population serves as a proxy for technological change in the sector. In many parts of the country, buffalo population is growing faster than of cattle. Moreover, milk yield of buffalo is higher than of indigenous cattle. To assess whether such a shift in herd structure could help increase milk yield, the percentage of milch buffaloes in the total milch stock was also considered as one of the factors in raising the milk yield. The potential gains from technology and shifts in herd structure cannot be realized if inputs such as feed and fodder and animal health care services are in short supply. Area under irrigation is considered as a proxy for continuous supply of green fodder. The role of institutions and infrastructure in dairy development is crucial as well. Dairy cooperatives have witnessed a significant growth in India and could possibly have an impact on milk yield. Their contribution was captured by including the intensity of primary dairy cooperatives in the regression equation. The number of veterinary institutions was included to represent animal health care.

The variables, COOP and VET were found to be highly correlated with each other and could not be accommodated together in a single regression. Therefore, two separate equations (Model 1 and Model 2) were estimated, the structural forms of which are given below:

YLD = F (CRBRED, BUF, HSIZE, IRR, COOP) …(1)

YLD = F (CRBRED, BUF, HSIZE, IRR, VET) …(2)

Random Effects Model (REM) regression, a technique which is consistent with panel datasets, was used for the estimation. The REM follows the assumption that the variation across entities (states) is random and uncorrelated with the independent variables included in the model. In order to ascertain the suitability of REM over Fixed Effects Model (FEM), which is an alternative method under such circumstances, Hausman test was carried out. The results of this test favoured REM. Further, Breusch Pagan LM test was carried out for ascertaining the suitability of REM over simple OLS estimation. The data was checked for heteroscedasticity and serial correlation. The LR test was conducted to diagnose heteroscedasticity, whereas, Wooldridge test was used to ascertain the presence of serial correlation. The corresponding test statistics indicated that both heteroscedasticity as well as serial correlation were present in the regressions (Annexure 2). These problems were overcome by obtaining robust estimates of standard errors through a STATA procedure that ensured that the levels of significance of coefficients were not affected adversely.

## Results and Discussion

### Key Trends and Patterns of Growth

#### Trends in Milk Production: All India

Increasing milk production has been a pre-eminent goal of India's dairy development since independence. In pursuing this objective, the dairy development planning process in the country has devised several interventions. The recent initiative of Perspective National Dairy Development Plan is the latest example. The dairy industry has undergone significant changes with milk production increasing from 17 million tonnes (Mt) in 1950-51 to 121.8 Mt in 2010-11 (BAHS, 2012). However, between 1951 and 1973, the growth rate in milk production was barely 1 per cent per annum. A significant turnaround in the sector unfolded during the 1970s, when milk production grew at an annual rate of 4.5 per cent. During this period, a mega programme, 'Operation Flood' for increasing milk production was launched. During the 1980s, the growth in milk production further accelerated to 5.4 per cent and this momentum has continued though with slight deceleration. This heralded the country into an era of import substitution and self-sufficiency towards the late-1990s. The availability of milk increased from 110g / person / day in 1972-73 to 263 g / person / day in 2010-11.

#### Regional Trends

There are significant regional variations in the structure of dairying in the country. In 2010-11, Uttar Pradesh with production of 22.4 Mt was the largest milk-producing state (18.4% of total) in India. Rajasthan (10.8%), Andhra Pradesh (9.2%), Punjab (7.7%), Gujarat (7.6%) Maharashtra (6.6%), Bihar (6.6%), Haryana (5.1%) were other significant milk-producing states (Table 1).

The share of Andhra Pradesh, Bihar, Gujarat, and Rajasthan in national milk production has increased in

**Table 1. Trends in milk production across states of India**

| State | Share in national milk production (%) | | CAGR: 1992-93 to 2010-11 |
|---|---|---|---|
| | 1992-93 | 2010-11 | (% per annum) |
| Andhra Pradesh | 5.35 | 9.19 | 6.68 |
| Assam | 1.14 | 0.65 | 0.52 |
| Bihar | 5.51 | 6.62 | 6.11 |
| Gujarat | 6.55 | 7.65 | 4.89 |
| Haryana | 6.41 | 5.14 | 2.68 |
| Himachal Pradesh | 1.05 | 0.90 | 2.38 |
| Jammu & Kashmir | 1.62 | 1.32 | 3.94 |
| Karnataka | 4.47 | 4.20 | 2.79 |
| Kerala | 3.26 | 2.17 | 0.73 |
| Madhya Pradesh | 8.42 | 7.01 | 3.16 |
| Maharashtra | 7.08 | 6.60 | 3.47 |
| Odisha | 0.94 | 1.37 | 7.27 |
| Punjab | 9.63 | 7.73 | 2.93 |
| Rajasthan | 7.91 | 10.86 | 4.86 |
| Tamil Nadu | 5.98 | 5.61 | 3.32 |
| Uttar Pradesh | 18.37 | 18.40 | 4.38 |
| West Bengal | 5.22 | 3.67 | 1.93 |
| India | 100 (57.9) | 100 (121.8) | 3.95 |

*Source*: Computed from BAHS (various issues)

*Note:* The figures within the parentheses show total milk production in million tonnes.

**Table 2. Share of different milch species in milk production across different states of India**

(in per cent)

| State | 1993-94 | | | | 2010-11 | | | |
|---|---|---|---|---|---|---|---|---|
| | Cattle | | Buffalo | Goat | Cattle | | Buffalo | Goat |
| | Cross-bred | Non-descript | | | Cross-bred | Non-descript | | |
| Andhra Pradesh | 5.8 | 23.0 | 71.2 | 0.0 | 17.6 | 10.1 | 72.3 | 0.0 |
| Assam | 17.0 | 66.0 | 13.5 | 3.6 | 27.7 | 56.7 | 12.8 | 2.9 |
| Bihar | 5.0 | 36.0 | 47.2 | 11.9 | 18.9 | 35.6 | 42.7 | 2.8 |
| Gujarat | 6.0 | 26.4 | 63.1 | 4.5 | 17.1 | 21.2 | 59.2 | 2.5 |
| Haryana | 4.4 | 13.3 | 80.3 | 2.0 | 9.4 | 6.0 | 83.6 | 1.0 |
| Himachal Pradesh | 18.3 | 26.5 | 51.2 | 4.0 | 46.9 | 13.8 | 34.8 | 4.4 |
| Jammu & Kashmir | 39.7 | 26.3 | 29.4 | 4.6 | 59.2 | 15.6 | 19.3 | 5.8 |
| Karnataka | 17.7 | 35.7 | 46.1 | 0.5 | 42.7 | 25.3 | 31.0 | 1.1 |
| Kerala | 73.1 | 15.9 | 5.5 | 5.5 | 93.8 | 0.9 | 0.8 | 4.5 |
| Madhya Pradesh | 3.4 | 38.1 | 51.1 | 7.5 | 6.6 | 37.8 | 50.1 | 5.5 |
| Maharashtra | 25.6 | 24.1 | 45.5 | 4.8 | 38.1 | 15.3 | 43.2 | 3.4 |
| Odisha | 31.0 | 49.2 | 19.5 | 0.4 | 43.5 | 42.5 | 13.7 | 0.2 |
| Punjab | 23.2 | 4.1 | 71.9 | 0.7 | 29.1 | 3.4 | 66.9 | 0.6 |
| Rajasthan | 0.0 | 37.0 | 52.2 | 10.8 | 6.9 | 31.1 | 50.0 | 12.0 |
| Tamil Nadu | 23.2 | 36.4 | 40.4 | 0.0 | 76.8 | 11.3 | 11.9 | 0.0 |
| Uttar Pradesh | 5.9 | 21.9 | 66.4 | 5.9 | 8.7 | 17.9 | 68.1 | 5.3 |
| West Bengal | 27.0 | 64.3 | 8.4 | 0.3 | 43.0 | 48.9 | 5.0 | 3.1 |
| All India | 14.2 | 27.7 | 53.7 | 4.4 | 24.3 | 20.8 | 51.2 | 3.8 |

*Source*: Computed by authors based on data from BAHS (various issues)



the past two decades while that of other states it has either remained stagnant or decreased. The growth in milk production across the states has depicted a diverse trend (Table 1). During 1992-93 to 2010-11, the growth in milk production was very impressive in the states of Odisha (7.3%), Andhra Pradesh (6.7%), and Bihar (6.1%). The states of Gujarat, Rajasthan, and Uttar Pradesh also recorded more than 4 per cent annual growth in milk production. This impressive growth trend in milk production suggests that dairying is becoming wide-spread across the country and its contribution in providing livelihood is increasing with time. The recent spurt in growth of milk production in Bihar and Odisha indicates the emergence of new centres of milk production in the country.

**Sources of Milk Production**

Cows and buffaloes are the main milch species and together contribute about 96 per cent to the total milk production in the country. Goats account for the rest. The relative shares of cattle, buffalo and goats in total milk production have not undergone any substantial change during the past two decades. However, significant changes have been noticed in some states like Bihar, Gujarat, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala and Tamil Nadu (Table 2). The general trend in all these states was a shift from buffalo to cow milk, the primary reason being increasing replacement of the non-descript cows with crossbred cows. Milk production from crossbred cows has been found growing at a higher rate than that from buffalo and non-descript cattle.

The changing composition of dairying population clearly indicated the growing contribution of crossbreed cows in milk production, from 14 per cent in 1993-94 to 24 per cent in 2010-11. Further, the share of crossbreeds in cattle milk production has been increasing consistently during the past two decades, with corresponding shares swelling from 31 per cent in 1993-94 to 53 per cent in 2010-11. As the process

of replacement of non-descriptive cows with improved crossbred cows is still progressing, the contribution of crossbreds to milk production is certainly expected to increase further in the times to come.

**Milk Yield**

India has the largest cattle and buffalo population in the world. The average yield of Indian cows is among the lowest, though the yield of Indian buffaloes is modest. The average milk yield of milch animals (cows and buffaloes taken together) is much less than the global average. The highest milk yield of over 25 kg/day is in Israel, followed by the USA (19 kg/day), the UK (15 kg/day) and Australia (12kg/day). In India, the average milk yield of milch animals (cattle and buffalo) was 2.71 kg/day in 1992-93, which rose to 3.36 kg/day in 2000-01 and further to 3.94 kg/day in 2010-11 (Table 3). Although, the yield of Indian milch animals is not strictly comparable due to diversity in the systems and management practices followed in different countries, their persistent lower yield cannot be overlooked. In India, milk yield grew by about 3 per cent per annum during the 1990s, but decelerated to 2 per cent during the 2000s.

**Table 3.Yield of animals in-milk across states**

| State | Milk yield (kg/day) | | Growth rate (%) |
|---|---|---|---|
| | 1992-93 | 2009-10 | 1992-93 to 2009-10 |
| Andhra Pradesh | 1.87 | 3.80 | 4.13 |
| Assam | 1.16 | 1.27 | 0.25 |
| Bihar | 2.58 | 3.42 | 1.27 |
| Gujarat | 3.47 | 4.63 | 1.63 |
| Haryana | 5.06 | 6.54 | 1.34 |
| Himachal Pradesh | 2.39 | 2.99 | 1.08 |
| Jammu & Kashmir | 2.81 | 4.51 | 3.01 |
| Karnataka | 2.11 | 3.22 | 2.31 |
| Kerala | 3.89 | 7.59 | 4.06 |
| Madhya Pradesh | 1.70 | 2.69 | 1.62 |
| Maharashtra | 2.50 | 3.62 | 2.74 |
| Odisha | 0.73 | 2.06 | 6.64 |
| Punjab | 5.83 | 8.88 | 2.16 |
| Rajasthan | 3.34 | 4.99 | 2.20 |
| Tamil Nadu | 3.07 | 5.13 | 3.21 |
| Uttar Pradesh | 3.00 | 3.93 | 1.76 |
| West Bengal | 2.24 | 2.76 | 1.67 |
| All India | 2.71 | 3.94 | 2.10 |

*includes cross-bred

*Source*: Computed from BAHS (various issues)

The regional differences in milk yield are also evident, which can be attributed to several factors. Firstly, the distribution of breedable bovine population differs significantly across the country and secondly, there are also wide differentials in resource base for feed, fodder, animal healthcare, artificial insemination facilities, etc. across states. Such factors are instrumental to a large extent in creating regional disparities in production and yield of milk across different states. In 2010-11, the yield of milch animals (cattle and buffalo) was highest in Punjab (9.1 kg/day), followed by Kerala (8.6 kg/day) and Haryana (6.8 kg/day) and was lowest in Assam (1.3 kg/day) in 2010-11. Other states like Himachal Pradesh, Madhya Pradesh, Odisha and West Bengal also have low yield (3 kg/day). However, in general, the yield of milch animals has increased over time irrespective of states. Impressive growth in milk yield was put up by states like Odisha (6.6%), Andhra Pradesh (4.1%), Kerala (4.1%) and Tamil Nadu (3.2%) during the period 1992-93 to 2010-11.On the contrary, the growth in milk yield was almost stagnant in Assam and West Bengal and modest in Karnataka, Uttar Pradesh, Punjab, Rajasthan, etc.

**Sources of Growth in Milk Production**

The impressive growth in milk production has been a matter of satisfaction and focus in the policy discourse on dairy development in India. However, development of dairying has not been uniform across the country. Significant regional disparities exist (Jha, 2004; Saikia and Kakaty, 2007). In order to empirically verify these regional differentials, this section has presented the quantification of contribution of various states to total incremental growth of milk production. Accordingly, growth in milk production during the period 1992-93 to 2010-11 was disaggregated to derive the contribution of individual states. Further, the growth arising due to change in livestock population, and productivity of livestock at the national level, has been examined with the help of decomposition analysis.

**Contribution of Different States to Growth in Milk Production**

The contribution of different states to incremental milk production between 1992-93 and 2010-11 has been listed in Figure 1. During this period, the milk production almost doubled, from about 58 Mt to 122 Mt. Uttar Pradesh alone accounted for more than 18 per cent of the incremental growth in national milk production. It was followed by Rajasthan with a contribution of over 13 per cent. The states of Andhra Pradesh (12.7%), Gujarat (8.7%), Bihar (7.6%) and Punjab (6.0%) have also contributed significantly to the additional milk production in the country during this two-decade period. These six states together contributed about 67 per cent to the additional milk production in the country. Madhya Pradesh and Maharashtra were the other states which contributed to the overall growth in milk production.

**Contribution of Changes in Population and Yield of Livestock**

Another dimension of looking at the sources of growth is to assess the contribution of dairying population and breed quality to the incremental milk production. The results have suggested that, between 1992 and 2010, about 57 per cent of the incremental production was contributed by increase in milk yield and 42 per cent by increase in population of milch animals. The crossbred cattle accounted for 35 per cent of the additional milk production and 12 per cent of this came from improvement in their milk yield (Table 4). On the other hand, indigenous cows contributed 15 per cent to the increment of which 74 per cent came

**Table 4. Share of yield and population of livestock to milk production growth**

| Animal type | Share in growth of milk production (%) | | |
|---|---|---|---|
| | Milk yield | Population | Interaction |
| Cross-bred cattle | 12.0 | 87.3 | 0.7 |
| Non-descript cattle | 74.2 | 25.4 | 0.4 |
| Total cattle | 61.2 | 37.8 | 0.9 |
| Buffalo | 40.1 | 59.0 | 0.9 |
| Goat | 58.5 | 40.9 | 0.6 |
| Total milch animals | 56.9 | 42.2 | 0.9 |

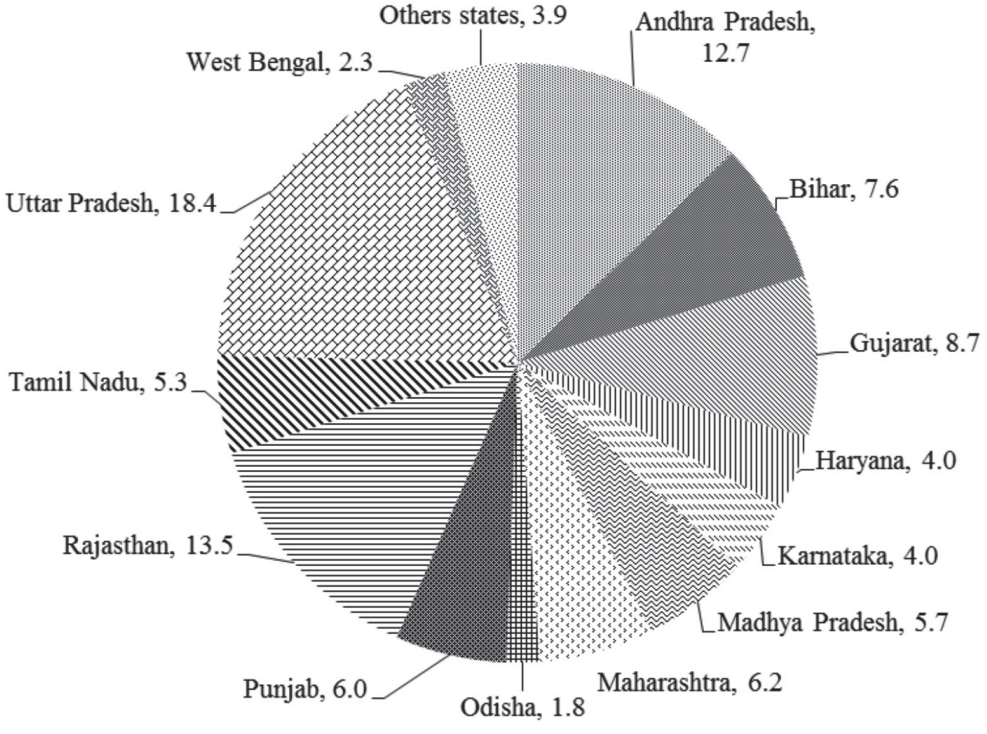


**Figure 1. Contribution of different states to the growth of milk production in India, 1992-2010**
*Source*: Computed from BAHS (various issues).

from enhanced milk yield. The buffaloes accounted for 50 per cent of the augmented milk production and their yield improvement contributed 40 per cent to it. These results indicate that the growth in milk production has come largely from replacement of low-yielding indigenous cows with crossbreds and high-yielding buffaloes.

The contribution of yield to output growth is the combined effect of technology and improvements in feed, healthcare and other management practices. In the case of crossbred/improved animals, milk yield is embodied as a general trait and therefore, the contribution of the crossbred/improved animals to incremental milk production may be attributed to the contribution of technological change. The potential of crossbred cattle and buffaloes is yet to be fully exploited and efforts should be made to bridge this gap. Better management of higher milk yielding breeds of indigenous cows such as *Sahiwal, Gir*, and *Tharparkar* can further increase the rate of growth in milk production. Demonstrably, these improved indigenous breeds have yield potential up to 2000 kg per annum.

The effect of technological, institutional and socio-economic advances on yield growth can be measured using the economic tool total factor productivity (TFP). Kumar and Pandey (1999) have estimated the TFP growth in the livestock sector for the period 1951 to 1995-96 and have found that growth in TFP accelerated after 1970-71(1.4% per year) compared to the pre-1970-71 period ( -0.4 % per year). During the post-1970-71 period, the TFP growth accounted for nearly 40 per cent of the output growth in the livestock sector.

**Determinants of Milk Yield**

As explained in the section on methodology, the determinants of milk yield were identified based on regression analysis with milk yield (YLD) as the dependent variable. The estimated coefficients, their levels of significance and robust standard error along with other econometric test statistics of the models 1 and 2 are presented in Table 5.

Both the equations were significant at 1 per cent level as was evident from the Wald chi$^2$ statistics and had reasonably good explanatory power indicated by the corresponding $R^2$ values. The coefficient for the variable CRBRED was found to be 0.159 in Equation (1) and 0.190 in Equation (2); both of them were significant at 1 per cent level. This corroborates the unflinching influence of crossbreds in improving milk yield in the country. Statistics show that the number of crossbred cows increased impressively at an annual rate of 6.7 per cent during the period 1993-94 to 2010-



**Table 5. Estimated Random Effects Model (REM) regression to identify determinants of milk yield**

Dependent variable: Milk yield per animal per day

| Explanatory variable | Equation 1 | | Equation 2 | |
|---|---|---|---|---|
| | Coefficient | Robust standard error | Coefficient | Robust standard error |
| Constant | -0.198 | 0.463 | -0.204 | 0.383 |
| Share of cross-bred (CRBRED) | 0.159*** | 0.034 | 0.190*** | 0.027 |
| Share of buffalo (BUF) | 0.007 | 0.018 | 0.006 | 0.017 |
| Herd size (HSIZE) | -0.031** | 0.009 | -0.025*** | 0.009 |
| Irrigated area (IRR) | 0.310** | 0.013 | 0.277* | 0.105 |
| Dairy co-operatives (COOP) | 0.070** | 0.035 | - | - |
| Veterinary institutions (VET) | - | - | 0.033 | 0.051 |
| No. of observations | 248 | | 302 | |
| Wald chi$^2$ | 109.6*** | | 92.27*** | |
| $R^2$– within | 0.58 | | 0.50 | |
| $R^2$– between | 0.60 | | 0.45 | |
| $R^2$– overall | 0.60 | | 0.45 | |

*Note:* *,**and *** denote significance at 10 per cent, 5 per cent and 1 per cent levels, respectively.
*Source:* BAHS (different years), *Livestock Census, Agricultural Statistics at a Glance*, GoI.

11 at all-India level (Annexure 3). Consequently, there was a consistent improvement in the quality of milch animals with resultant gains in milk yield. This finding is consistent with other past studies, such as of Birthal *et al.*, (1999). In contrast, both the coefficients pertaining to the variable, BUF were found to be non-significant.

Another notable finding was the negative and significant coefficient for HSIZE in both the equations. Though the herd size in most of the states decreased over time, evidences suggest that the quality of herd improved due to replacement of traditional breeds with better yielding breeds, with positive outcomes on milk yield. The better management of smaller herds might have also contributed towards improving yield levels. The milk yield was also found to improve significantly with increase in area under irrigation (IRR), which was a proxy variable for fodder availability. The level of irrigation has an important role in ensuring year-round availability of fodder, thereby augmenting milk yield. Cultivated fodder is an important source of green fodder, but area under fodder is very limited in the country. Presently, only 0.026 ha area per bovine animal is put under fodder crops to meet the fodder requirement. Therefore, the fodder cultivation should be accorded higher priority and state policies should be tuned to encourage more farmers to take up fodder farming.

The coefficient pertaining to the variable dairy co-operatives (COOP) was found significant at 5 per cent level and indicated their influence in improving milk yield through providing better facilities for quality, storage, marketing, processing, and other related services for the dairy farmers. As evident from statistics, the number of dairy co-operatives increased substantially from 63,415 in 1990-91 to 1,44,200 in 2010-11 with the associated increase in farmer-members from 7.48 million to 14.46 million and milk procurement from 3.54 Mt to 9.6 Mt during this period. However, cooperatives have been found working effectively only in a few states like Gujarat, Maharashtra, Karnataka, Kerala, Tamil Nadu, etc. and in spite of their tremendous growth, only 10 per cent of the dairy farmers could be associated with them. Therefore, efforts are required to spread the success of dairy co-operatives to more states so that the advantages of collective action can be harnessed for better performance in the sector. While the influence of dairy cooperatives on milk yield was apparent, the variable VET in Equation (2), denoting the veterinary infrastructure, turned out to be non-significant, suggesting inadequacy of the existing veterinary facilities in bringing about a perceivable dent in milk yield.

Though yield enhancement in the sector is directly driven by the factors like share of crossbreds in animal stock, herd size, area under irrigation, dairy co-operatives, etc., as discussed above, the indirect influence of dairy infrastructure and other associated variables cannot be overlooked. Even though the variable VET *per se* had an insignificant contribution in raising the milk yield, its role in supporting the primary variables was worth examining. For instance, growth in the number of cross-bred cattle and high-yielding buffaloes has depicted a close association with the number of AI centres, veterinary facilities available and personnel deployed for providing these services. However, the veterinary infrastructure in the country has been found in a poor state of affairs. There is only one veterinary institute for nearly 5800 animals (Table 6). Further, these institutes do not have adequate number of trained veterinary professionals. There is roughly one veterinarian for each veterinary institute and consequently, a large number of animals do not get veterinary care at appropriate time and place.

**Table 6. Status of infrastructure and other variables related to performance of dairy sector**

(in No.)

| Particulars | 1992-93 | 2010-11 |
|---|---|---|
| Bovine animals served per veterinary institute | 7632 | 5799 |
| Bovine animals per veterinary person | 9219 | 5627 |
| Total AI centres | 39600 | 55806 |
| AIs performed per 1000 milch animals | 155 | 373 |
| Adult female bovine per AI centre | 2727 | 1807 |
| Bovine breeding farms | 183 | 199 |
| Semen production centres | 148 | 172 |
| Frozen semen banks | 91 | 184 |
| Liquid nitrogen plants | 151 | 91 |

Source: Basic data from BAHS (different years), *Livestock Census, Land Use Statistics, Agricultural Statistics at a Glance, Population Census*, GoI.

However, facilities for artificial insemination (AI) are more abundant than veterinary facilities and there is one AI centre for about 1800 adult female bovines. Thus, about 33 per cent of the animals can be artificially inseminated each year. However, because of the low success rate of AIs, only about 20 per cent of the adult females are being inseminated artificially with the existing infrastructure. A little more than one-fourth of the cows-in-milk are presently crossbred and the demand for crossbred species is increasing rapidly. The infrastructure for developing high-yielding bovines and cross-breds has been found limited. There are only about 200 bovine breeding farms (cattle and buffalo) in the country. The number of semen production centres, frozen semen banks, liquid nitrogen plants, etc. is also grossly inadequate. All these facts point to the vast scope in improving the veterinary infrastructure in the country for realizing better performance. Higher investments and appropriate policy support are therefore required to bring about the perceivable results in the area of milk production.

## Conclusions and Policy Implications

The study has revealed that India has made significant strides in enhancing milk production and yield, particularly during the past two decades. The structural changes in production of milk have been quite visible and the composition of dairy animals has tilted in favour of improved crossbred cattle and better-yielding buffaloes. The role of some new states in augmenting milk production in India is also apparent. The growth in milk yield has been considerable and is reflected in its contribution to output growth. More than half of the growth in milk production during the past two decades has been contributed by the growth in milk yield. The major determinants of milk yield include technological change and quality of herd, irrigation development, expanding network of dairy cooperatives, etc.

Achieving a higher growth in the dairy sector is essential to ensure long-term inclusive agricultural growth. Productivity-led growth is the only viable option for accelerated and sustainable growth of the sector. The study has pointed out several avenues and strategies for policy intervention to support dairy development for enhanced milk yield. The analysis has provided a strong case for continued investments in improved breeds of cattle and buffalo. It has been shown that improved animal species have been critical to milk yield enhancement. The study has shown a negative relationship between herd size and milk yield, the underlying hypothesis being improvement in herd quality and better management lead to yield growth despite decrease in herd size. The study has also brought out the positive impact of dairy cooperatives on milk yield by facilitating integration between rural producers and urban consumers and through fostering new technology. However, the status of veterinary and animal healthcare infrastructure and the delivery of these services are still poor and concerted efforts are required to bring about further progress. The strengthening of market linkages through expansion of cooperatives, and facilitating new models of dairy farming would go a long way in further improving milk yield in the country.

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**Annexure 1**

**Mean and standard deviation of explanatory variables (year)**

| Explanatory variable | Mean | Standard deviation |
|---|---|---|
| Share of cross-bred in milch animal (%) | 19.83 | 21.48 |
| Share of buffalo in milch animal (%) | 33.03 | 26.73 |
| Herd size (No.) | 2.97 | 3.51 |
| Irrigated area (%) | 40.33 | 26.43 |
| Dairy co-operative societies (No. per '000 bovine units) | 0.74 | 0.72 |
| Veterinary institutes& hospitals (No. per '000 bovine units) | 0.69 | 1.09 |

**Annexure 2**

**Econometric tests associated with regression and their results**

| Test | Statistic | Null hypothesis | Model 1 | Model 2 |
|---|---|---|---|---|
| Hausman test | $Chi^2$ statistic | REM preferred over FEM | $3.61^{ns}$ | $2.28^{ns}$ |
| Breuch Pagan LM test | $Chibar^2$ statistic | OLS preferred over REM | $1233^{***}$ | $1499^{***}$ |
| LR test for heteroscedasticity | LR $Chi^2$ statistic | Homoscedasticity | $275.6^{***}$ | $388.2^{***}$ |
| Wooldridge test for autocorrelation | F statistic | No first order autocorrelation | $5.27^{**}$ | $11.52^{***}$ |

*Note*: ns denotes non-significant

** and *** denote significance at 5 per cent and 1 per cent levels, respectively

**Annexure 3**

**Annual growth rate in factors associated with milk yield: 1993-2010**

| Particulars | Trend growth rate (%) |
|---|---|
| Cross-bred cows | 6.74 |
| Buffaloes | 1.97 |
| Herd size (No./household) | -0.49 |
| Irrigated area (%) | 1.32 |
| Membership of dairy co-operative societies | 2.97 |
| Number of veterinary institutes | 0.90 |