

# Milk Production efficiency and its Determinants in Madhya Pradesh

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**Abstract:** Dairying is the important segment of the livestock which is the usable option for diversifying the agricultural economy. India has been a leading producer of Milk for extended period. The study was undertaken in the Madhya Pradesh. The study focusses on analyzing the trend of milk production in Madhya Pradesh. It also focusses of the impact of various variables associated with technical efficiency of milk yield. Despite the impressive growth in milk production in the state, due to the increase in adoption of cross breed cow and change in composition of animals, this the gross value addition in livestock is declining continuously. It is found in the study that the variables like labor use, green fodder and grain use have a positive impact on efficiency of milk yield and use of dry fodder negatively impact the efficiency of milk yield in Madhya Pradesh.

**Keyword:** Growth, Livestock, Milk Yield, Efficiency, Stochastic production frontier, Madhya Pradesh

## INTRODUCTION

India is a predominately rural country about 70 per cent of the population belongs to rural areas (Chand, et. al. 2017). Agricultural sector of India is an integral part of its economy. Indian agriculture is diversified farming system in which crop production and animal husbandry devoted for efficient and economic utilization of land, labour and capital (Sharma et.al., 2018). At present near about 44.15 per cent workforce of India is engaged in agriculture for their livelihood (NSO-PLFS, 2019). Livestock is second highly adopted activity after crop cultivation. Most of the farmers depend on their livestock for farming purpose or as a secondary source of income. In the recent past decades, due to dairy farming of India has seen tremendous growth in agriculture sector (Srivastva, et. al. 2020; Chand and Raju, 2008). Dairy farming is one of the fastest growing sectors of India which provide employment and nutritional security as well. India's milk production has increased manifold in past

decades. Although in the last financial year the performance of this sector has declined than the major milk producing countries mainly Denmark, Israel, Canada and the United Kingdom.

In 2018, India stood at 98th out of 200 countries in the world in terms of milk production per dairy animal (FAO, 2018) but the situation was not satisfactory. However, the domestic consumption of milk and its related products increased. There is a symbiotic relationship between the agricultural sector and dairy farming as the agricultural sector provides fodder (green and dry fodder) and the dairy farming sector provides milk, manure etc. The increased growth rate of this sector also changed social and economic factors of India. After 2014-15, the growth rate of this sector was more than 6 per cent while the growth rate of agriculture and allied sector declined significantly (economic survey, 2020). Livestock farming contributes more than 28 per cent to the agricultural and allied sector's output in India (NAS, 2020).

There is a significant difference in milk production of states due to climatic variations and geographic large size (Landes et al 2017). The average milk production of agricultural developed states mainly Punjab, Haryana etc. was almost doubled (*Annual Report 2017-18*, Department of Animal Husbandry, Dairying and Fisheries, Government of India) than lagged beheaded states like Madhya Pradesh and Maharashtra. However, in Madhya Pradesh, the livestock sector has grown by more than 14 per cent (NSA, 2020). Madhya Pradesh ranks second in the country's total cattle population with 10.2 per cent of the country's total cattle population (GoI, 2014). Dairy farming became an important secondary source of income and generate employment opportunities. This reason has brought the attention of many researchers for detailed study of this sector. However, there are different issues some are area specific while some are common. The present study is intended to understand these issues and Challenges faced by dairy stakeholders. The objectives of the study are to find out the rapid growth of milk production and livestock in Madhya Pradesh. And also identify the determinants of milk productivity in Madhya Pradesh. This research has examined the changing composition of milking animals in Madhya Pradesh.

## DATA AND METHODOLOGY

The study is based on the unit-level data of cost-of-cultivation survey data which was conducted under a centrally sponsored scheme of the Indian Governments Ministry of Agriculture, entitled "Comprehensive Scheme for Studying Cost of Cultivation/Production of Principle Crops in India". In the study, we compiled three years that is 2017-18, 2018-19 and 2019-20 data to estimate the efficiency model. 450 farmer's families survived under this scheme, and we generate panel data for those farmers who reported in all three years. The study examines the trend of milk production from 2000-01 to 2021-22 in Madhya Pradesh using Animal Husbandry Statistics (various years). The study hypothesis is that changes in efficiency in milk production is attributed due to change in various

factors including labour cost, use of dry and green fodder, use of grain, use of mineral salt etc. the changes in these factors were examined and their association with milk production by fitting stochastic frontier production function with determinants of inefficiency. Thus, the model estimates both technical efficiency and time-varying technical inefficiencies. The empirical form of the model is given below: model is given below:

$$\begin{aligned} \ln\_Yield_{it} = & \beta_0 + \beta_1 \ln\_Labour_{it} + \beta_2 \ln\_GFodder_{it} + \\ & \beta_3 \ln\_DFodder_{it} + \beta_4 \ln\_Grain_{it} + \beta_5 \ln\_MFeed_{it} + \beta_6 \\ & \ln\_Oilcake_{it} + \beta_7 \ln\_Mineral_{it} + \beta_8 \ln\_HCost_{it} + \beta_9 \\ & \ln\_Vcost_{it} + \beta_{10} \ln\_Ocost_{it} + (V_{it} - U_{it}) \end{aligned}$$

where,

$\ln\_Labour_{it}$  = Log of Labour use (hr/animal/annum)

$\ln\_GFodder_{it}$  = Log Green fodder use (Qtl/animal/annum)

$\ln\_DFodder_{it}$  = Log Fodder dry use (Qtl/animal/annum)

$\ln\_Grain_{it}$  = Log Grain use (Kg/animal/annum)

$\ln\_MFeed_{it}$  = Log Mixed feed use (Kg/animal/annum)

$\ln\_Oilcake_{it}$  = Log Oilcakes & other concentrate use (Kg/animal/annum)

$\ln\_Mineral_{it}$  = Log Mineral salt use (Kg/animal/annum)

$\ln\_HCost_{it}$  = Log Cost Heading (Rs. /animal/annum)

$\ln\_Vcost$  = Log Cost Vaccination (Rs. /animal/annum)

$\ln\_Ocost_{it}$  = Log Cost Other any (Rs. /animal/annum)

The subscript<sub>it</sub> denotes ith the observation in t<sup>th</sup> year, and Ln denotes the natural logarithms.  $V_{it}$  is assumed to be the independent and identically distributed (iid) random errors, having normal  $N(0, \sigma^2v)$  distributed and independent of  $U_{it}$ .  $U_{it}$  represents technical inefficiency and is assumed to be a non-negative truncation of the half normal distribution  $N(\mu, \delta^2)$ .  $V_{it}$  captures the stochastic effects outside the control of farmers whereas  $U_{it}$  measures shortfall of observed output from

its maxim possible value (estimated through stochastic frontier function).

It is further assumed that the average level of technical inefficiency as measure by ( $U_{it}$  is function of various variables.

$$U_{it} = \delta_0 + \delta_1 HH\_Age_{it} + \delta_2 HH\_Education_{it} + \delta_3 F\_Size_{it} + \delta_4 N\_Animal_{it} + \delta_5 Inmilch\_animal_{it} + \delta_6 Trend_{it}$$

$HH\_Age_{it}$  = Age in years of  $i^{th}$  household head at  $t^{th}$  time

$HH\_Education_{it}$  = Education in years of  $i^{th}$  household head at  $t^{th}$  time

$F\_Size_{it}$  = Number of family members in  $i^{th}$  household at  $t^{th}$  time

$N\_Animal_{it}$  = Number of animals in  $i^{th}$  household at  $t^{th}$  time

$Inmilch\_animal_{it}$  = Number of inmilch animals in  $i^{th}$  household at  $t^{th}$  time

$Trend_{it}$  = Dummy variable to control the Trend

## RESULTS AND DISCUSSION

The path of growth of the agriculture sector of Madhya Pradesh was very magnificent (Singh, et. al. 2018). Growth of agriculture sector led to the development of the state. Growth of agriculture trailed the overall growth of the economy of the state. The agriculture sector (included crop and livestock) witnessed the growth at 5.82 per cent and 16.73 per cent growth during the year 2002-03 to 2009-10 and 2009-10 to 2014-15 (Singh, et. al. 2019). The contribution of livestock to agriculture increased from 10.9 per cent in 2011-12 to 21.04 per cent in 2021-22 in Madhya Pradesh (GoI, 2021). Madhya Pradesh is the third largest milk producing state in India with total production of 15.19 million tonnes, which is around 8.5per cent of total production of country during 2018-19 (NDDB, 2019). The milk production is affected by various variables like type of breed, feed intake, efficiency practices, vaccination cost. The change in these variables and their effects on the milk production have been analyzed using the stochastic frontier function with the inefficiency model. The summary statistics of the variable used in the model is presented in the Table 5

**Table 1: Milk production in Madhya Pradesh Over time**

Year	Milk production in 000 tonnes			
	Cows	Buffaloes	Goats	Total
2000-01	1857	2593	311	4761
2001-02	2115	2841	327	5283
2002-03	2138	2870	335	5343
2003-04	2163	2887	338	5388
2004-05	2276	2890	340	5506
2005-06	2373	3402	508	6283
2006-07	2437	3491	500	6428
2007-08	2501	3580	491	6572
2008-09	2799	3661	395	6855
2009-10	2992	3758	417	7167
2010-11	3152	3935	427	7514
2011-12	3589	4041	519	8149
2012-13	3992	4309	536	8837
2013-14	4377	4679	543	9599
2014-15	4982	5240	557	10779
2015-16	5930	5610	609	12149
2016-17	6551	6202	692	13445
2017-18	7155	6820	738	14713
2018-19	7751	7363	797	15911
2019-20	8324	7927	858	17109
2020-21	8490	8599	911	18000
2021-22	8979	9063	962	19004

Source: Basic animal husbandry statistic (Various issues)

Livestock plays an important role in rural economy and their livelihood. The above table reflects the trend of milk production in Madhya Pradesh over the period of time from 2000-01 to 2021-22. Overall milk production of cows, buffalo, and goats have increased from 4761 to 19004 tones which is almost five-fold. The table also reflects that the major composition of total milk production is coming from buffalo, followed by cow and goat till 2014-15 but after this time period cow's milk production have crossed the buffalo till 2019-20 but again after 2020-21 the share of buffalo in total production of milk have crossed cow's milk production in Madhya Pradesh. Goat share in total milk production is least as compared to other two.

**Table 2: Changing composition of milking animal in Madhya Pradesh**

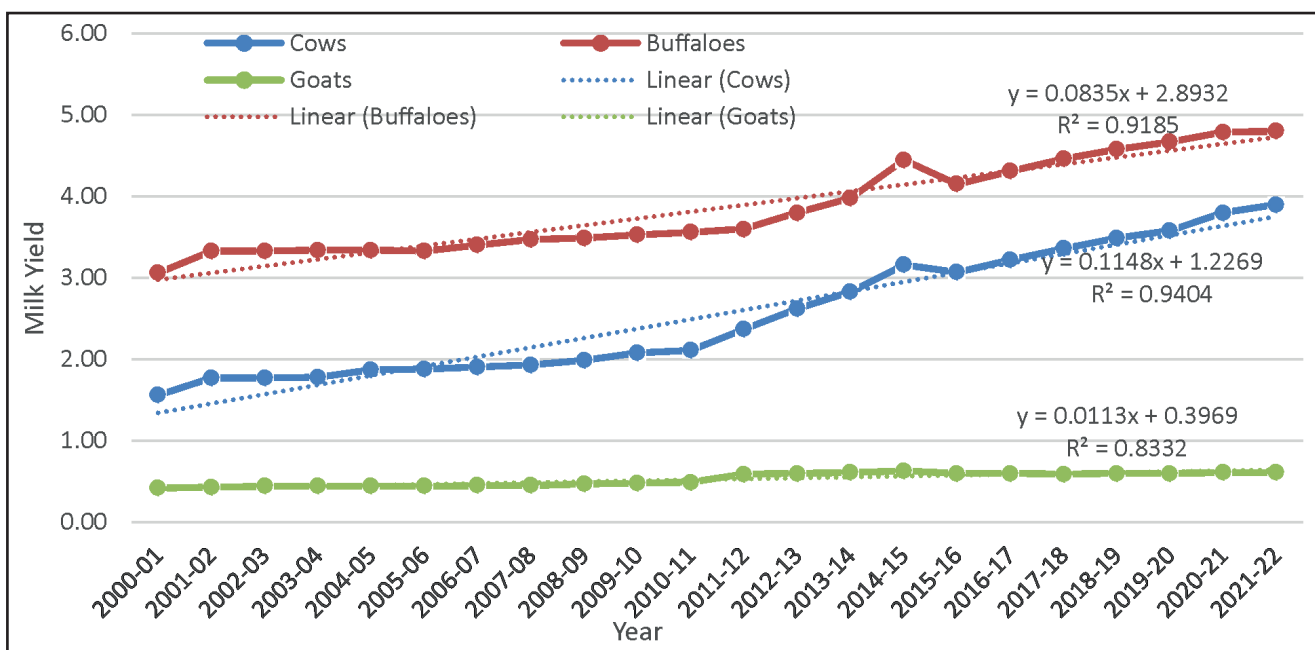
Year	Share in per cent				Total Animal (in 000)
	Cows			Buffaloes	
	Exotic/Cross-breed	Indigenous/Non-descript	Total		
2000-01	2.2	97.8	58.4	41.6	5579
2005-06	3.0	97.0	55.3	44.7	6249
2010-11	5.1	94.9	57.4	42.6	7115
2015-16	8.4	91.6	58.9	41.1	9003
2020-21	10.6	89.4	55.4	44.6	11038
2021-22	11.6	88.4	54.9	45.1	11488

Source: livestock census (Various issues)

As we have seen in previous Table 1 that the milk production has increased five-fold which can be due to the reason of change in composition of milking animal and increase in exotic/ cross breed cows as it produces more milk as compared to indigenous cows. The table 2 presents the changing composition of milking animal in Madhya Pradesh. In the initial year 2000-01, total animal constitutes 58.4per cent of cows and 41.6per cent of buffaloes which has increased to 54.9 per cent of cows and 45.1 per cent of buffaloes in 2021-22. Exotic/ Cross breed cows in the state are only 11.6 per cent. The remaining 88.4 per cent are indigenous during

the 2021-22 due to the high maintenance cost of exotic cows which is difficult to be adopted.

Figure1 presents the trend of milk yield per liter per day over the time period in Madhya Pradesh. All the trend lines in the figure shows that there is increase in the milk yield by all the three milking animals that includes buffalo, cow and goat. It also shows that milk yield of cow is fastest as compared to the buffalo and goat which concludes that cow milk dominates the total milk productivity in the region. With every additional year there is increase in cows yield by 0.115 liter. Milk productivity of goat remained almost stable during the study period.



**Figure 1: Trends of milk yield (liter/day) over time in Madhya Pradesh**



**Table 3: Growth rates of number of animals, milk production and Yield in Madhya Pradesh between 2000-01 and 2020-2021**

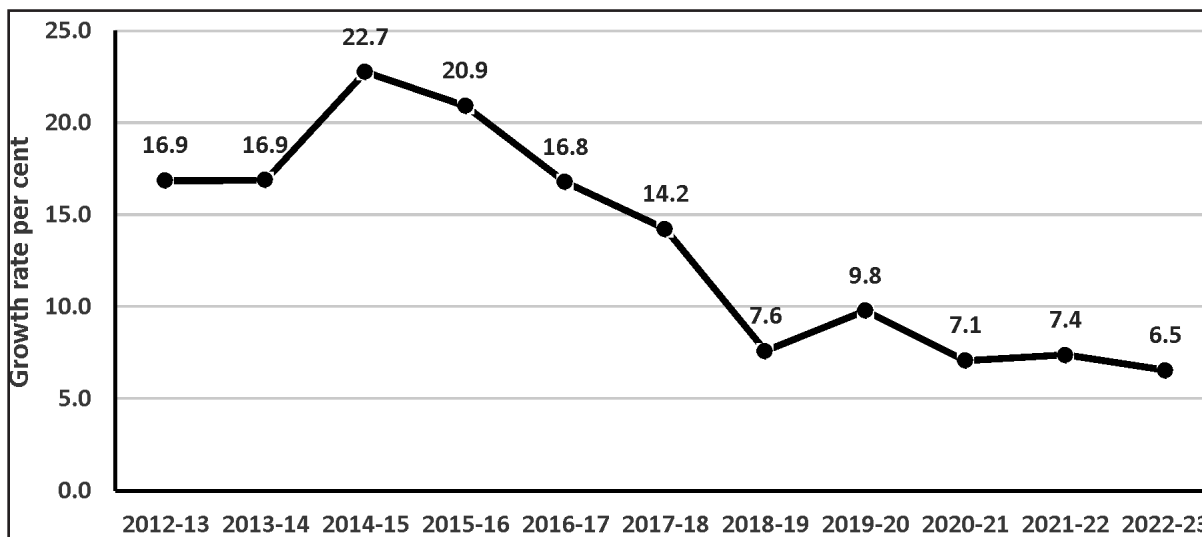
Particular	Growth rate in per cent		
	Cows	Buffaloes	Goats
Number of animal	3.69	3.87	3.04
Production of Milk	8.46	6.11	5.26
Yield (Litre/ day)	4.60	2.16	2.21

Source: author's estimation

The table 3 reflects the growth rate of number of milking animals, production and yield shown between the years 2000-01 to 2020-21. There is highest increase in the number of buffaloes which stood at 3.87 followed by cow which stood at 3.69. It also highlights that growth rate in the milk production of cow is highest

which stood at 8.46 and yield at 4.60 per cent. The buffalo's growth rate in the milk production stood at 6.11 per cent and yield at 2.16 per cent. The lowest growth rate increment was seen in the milk production and yield of goat. It shows that there was overall increase in the percentage of cows, buffaloes and goat which led to the increase in the contribution of this particular sector in Madhya Pradesh

The figure 2 reflects the growth rate of gross value-added livestock in Madhya Pradesh. It shows that the trend in the growth rate is declining over the period of time. Initially it was 16.9 per cent which declined to 6.5 per cent during the study period. this shows that pace of growth is declining during the study period in spite the increase in the milk production

**Fig. 2: Growth rate of gross value added livestock in Madhya Pradesh (Y-o-Y change)****Table 4: Average value, Livestock output and Input use in Madhya Pradesh in TE 2019-20**

Particulars	Average Value	Upper limit	Lower limit
Milk yield (Litter/ animal/ annum)	498.6	545.3	451.9
Animal power production (Hrs/animal/ annum)	1.8	3.1	0.4
Labour use (Whr/animal/ annum)	464.5	491.6	437.3
Fodder dry use (Qtl/animal/ annum)	13.5	14.1	12.8
Fodder green use (Qtl/animal/ annum)	7.8	8.3	7.2
Grain use (Kg/animal/ annum)	13.2	20.7	5.8
Mixed feed use (Kg/animal/ annum)	12.3	16.2	8.4
Oilcakes & other concentrate use (Kg/animal/ annum)	52.8	82.7	22.9
Mineral salt use (Kg/animal/ annum)	1.7	2.0	1.4
Value Milk output (Rs.)	18918	20652	17185
Value Animal Power production (Rs.)	89.0	155.7	22.2
Cost Heading (Rs.)	126.8	182.2	71.5
Cost Vaccination (Rs.)	4.4	6.7	2.0
Cost Other any (Rs.)	38.0	51.7	24.2

Source: author's estimation

The above table highlights the maximum and minimum limit of the various variables during 2019-20 in the study region. The milk yield ranges from 545.3 to 451.9 liter. The average value of animal power production stood at 1.8 hours. The use of labour ranges from 491.6 to 437.3 hours. The average use of dry fodder stood at 13.5 quintal and green fodder at 7.8 quintal. The average use of grain per animal was 13.2 kg and mixed feed was 12.3 kg. The use of oilcakes and other concentrates ranges from 82.7 kg to 22.9 kg per animal. Average use of salt was 1.7 kg. The average cost of heading was Rs. 126.8. The maximum and minimum cost of vaccination was Rs. 6.7 and Rs 2. Other cost ranges from Rs. 51.7 to Rs. 24.2.

Enhancement of efficiency in milk production is an important source of raising the level of yield at given level of input. The estimated value of  $\gamma$  was 0.945 and was significant at 1per cent level of significance. The predicted average efficiency in milk production was estimated to be 62.29 per cent this implies there exists the inefficiency in the model. The use

of additional labor has a positive impact of the production and is significant at 1per cent level of significance. Additional use of one labor leads to increase in milk production by 48.47 per cent. As more labor is employed more maintenance is done. Another variable is green fodder which also have a positive impact on the efficiency of the milk production and is significant at 1per cent level of significance. As there is increase in the use of green fodder, it leads to increase in milk production by 6.87 per cent this gives the evidence that it promotes more balanced and nutrition rich diet raising the level of milk yield. Dry fodder use has a negative impact on the milk production and is significant at 1per cent level of significance. The increase in grain use by 1per cent leads to increase in milk production by 14.29 per cent. another variable is herding cost which have a positive impact on the milk yield and is significant at 1per cent level of significance. Vaccination cost have a negative impact on the milk production and is not significant at 1per cent level of significance. This reflects the poor health of the animal which affects the milk yield

**Table 5: Results of stochastic production frontier**

<i>Stochastic Production Function Model</i>		<i>Inefficiency Model</i>	
<i>Variable</i>	<i>Coefficient</i>	<i>Variable</i>	<i>Coefficient</i>
Intercept	2.950*** (0.385)	Intercept	-13.279*** (10.078)
Ln Labour use	0.4876*** (0.0653)	Household head age	-0.03*** (0.017)
Ln Green fodder use	0.0687*** (0.0307)	Household head Education	-0.196*** (0.092)
Ln Dry fodder use	-0.0691** (0.0402)	Family Size	-0.405*** (0.195)
Ln Grain use	0.1276*** (0.0199)	No of Animal	0.291*** (0.109)
Ln Mixed feed use	0.1429*** (0.0182)	In-milch animal as per cent to total	0.103*** (0.087)
Ln Oilcake concentrate use	0.1817*** (0.0146)	Trend dummy for year	0.352*** (0.294)
Ln Mineral salt use	0.2193*** (0.0516)		
Ln Herding cost	0.0452*** (0.016)		
Ln Vaccination cost	-0.0105 (0.0352)		
Ln Other cost	0.0555*** (0.0129)		
Sigma-squared ( $\sigma^2$ )		4.218***	
Gamma ( $\gamma$ )		0.945***	
Number of observations		712	
Log-likelihood function		-761.122	
LR test		100.529***	
Estimated average technical efficiency		0.6229	

Source: author's estimation

of the animal. The economics of milk production is important due to the fact that it identifies the causes of inefficiency (Chand et.al., 2017).

The gamma squared value shows that there still exists the inefficiency. The models estimate the various determinants of the inefficiency. The age of the head has a negative inefficiency. As the age of the person increases by one year, the efficiency in the mil yield increases by 0.03 per cent. it is due to the fact as the age of the person increases, he becomes more experienced. Another determinant of inefficiency is found to education of head. Education of the head have a negative inefficiency on milk yield. As the person is more educated, he has a better knowledge, which underscores the need of better education related to animal husbandry practices. Family size was not found to be the significantly

associated with the inefficiency. If there is large family size there is availability of more labor for animal husbandry practices. Hence positively related with efficiency of milk yield. The number of animals does not have negative impact of inefficiency. More animals mean more milk yield. More of the In-milch animals as the percentage of total animals will leads to more of milk yield thus leading to increase in efficiency of milk production.

The cumulative distribution shows about 22 per cent farmer's efficiency levels below 50 per cent. It implies that there was chance to enhance the milk yield almost double-fold. It also observed that only 22 farmers had an efficiency level greater than 80 per cent. So the future scope of milk production through efficiency enhancement looking bright.

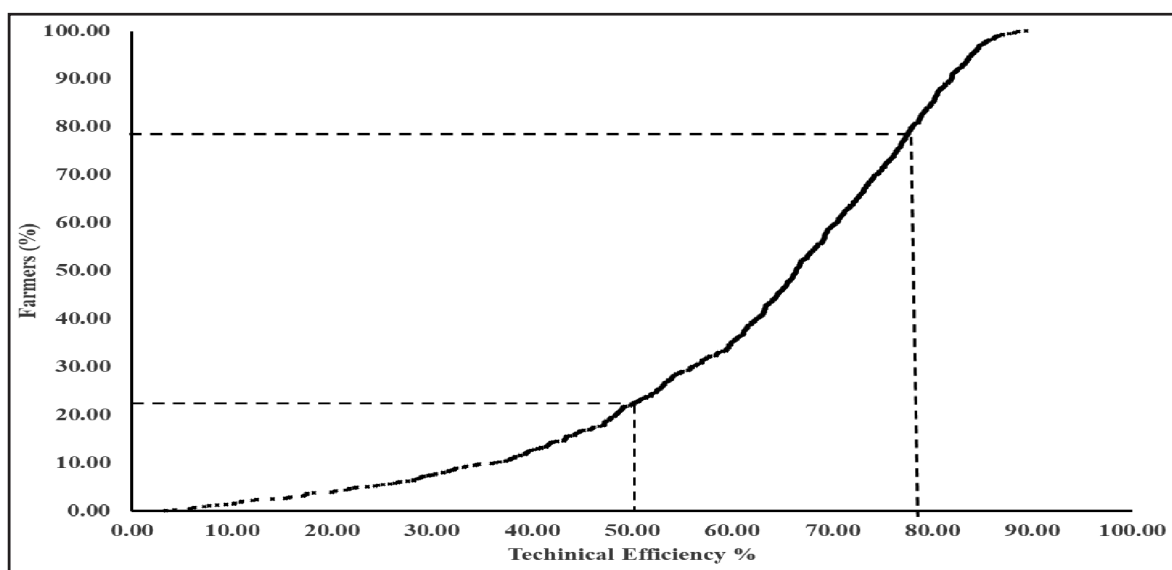


Fig 3: Cumulative Distribution Curve of estimated technical efficiency in milk production in Madhya Pradesh during TE 2019-20

Table 6: estimation of yield gap and gain

Particular	Values
Average efficiency level per cent	62.29
Maximum efficiency level per cent	89.39
Yield Gap per cent	30.3
Actual Yield (litter/animal)	497.5
Yield Gap(litter/animal)	150.8
Potential Yield (litter/animal)	648.4
Gap reduced at 1 per cent efficiency improvement in litter	4.98
Number of in milch animal (million)	11.49
Total milk Gain (000 tonnes) at 1 per cent improve in efficiency	57.16
Milk rate (average value of product for the same period)	36.6
Gross gain at 1 improve in efficiency (Rs. crore)	208.9

Source: author's estimation

The growth in the demand of milk and milk products offers good opportunities for small business holders to increase their income by increasing the efficiency in their milk production (Kumar et.al., 2014). Based on the technical efficiency it is found that the average efficiency level stands at 30.3 per cent. There is scope of improvement in efficiency level by 30.3 per cent without increasing the existing level of inputs. The maximum level of efficiency is 89.39 per cent. The actual yield is 496.5 litter per animal. There exists the yield gap of 150.8 litter per animal. If there is increase in efficiency by 1per cent this can lead to the improvement in yield by 4.98 per cent per litter. Increase in 1per cent efficiency can lead to 57.16 tones gains in milk. Gross gain of Rs. 208.9 crores are expected with increase in 1 per cent of efficiency. So, if the inefficiency is controlled there can be physical as well as economic gain.

## CONCLUSION

The study has founded that the milk production in Madhya Pradesh state was growing significantly during the last two decades. This growth was due to the change in composition of livestock. As founded in the study the number of buffaloes and Exotic/Cross-breed cows increased and both have more milk productivity and indigenous cows have less productivity. As a result, the milk production was increased around four fold during last two decades. However, the pace of the gross value added by the livestock was slow and passed through the diminishing returns phase. The results of stochastic production frontier established that most of the inputs was significantly responses to yield enhancement. Therefore, for future growth of the milk sector the state needs to promote farmers to provide extra minerals and salts, because the study established that it was the highest responsiveness after labor use.

The level of efficiency of milk production did not reach its trajectory level and there was a more than 30 per cent gap in yield, providing future scope to sustain growth. If the state that provides livestock extension activities and farmers tries to control the factors as suggested in the study, it will gain a lot. If, only one percent

efficiency level enhances, the extra 208.9 crore will add in the value addition of the milk output, without enhancing any cost. It will happen due to the production technology following the frontier farmers.

**Disclaimer:** Views expressed in the paper are personal.

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