

# Resource use efficiency in milk production in different dairy-integrated farming systems in Terai Region of West Bengal

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**Abstract:** The study was undertaken in the Terai region of West Bengal with the objective to assess the resource use efficiency in milk production in different dairy-integrated farming systems. The study covered a total of 180 dairy farmers from different farming systems. The results revealed that milk production in Dairy (D), Dairy + Crop + Goat (D + C + G), Dairy + Crop + Mushroom (D + C + M) and Dairy + Crop + Fishery (D + C + F) farming systems could be increased by feeding more amount of green fodder. Similarly, dry fodder had a positive effect on milk production in Dairy + Crop (D + C), Dairy + Crop + Goat (D + C + G) and Dairy + Crop + Poultry (D + C + P) farming system whereas in Dairy (D) farming system it had a negative impact on milk production. The study also revealed that green fodder was under-utilised and concentrate was over-utilised in Dairy + Crop + Mushroom (D + C + M) farming system. In Dairy + Crop + Fishery (D + C + F) farming system concentrate was over-utilised. In overall farming system, concentrate was over-utilised in indigenous cattle in the study area, resulting in a higher per litre cost of milk production.

**Keywords:** Cobb-Douglas Production Function, Marginal value product, Resource use efficiency

## Introduction

One of the integral parts of India's agriculture sector is the livestock sector which grew at a CAGR of 7.9% during 2014-15 to 2020-21 (at constant prices), and its contribution to total

agriculture GVA (at constant prices) has increased from 24.3% in 2014-15 to 30.1% in 2020-21 (Economic Survey 2022-23). Livestock population has increased between 2012 to 2019 from 30.35 million to 37.40 million in the state of West Bengal, registering a positive growth of 23.22 % in the total number of animals of various species (20<sup>th</sup> Livestock Census, 2019). Though livestock density is higher (730 per square km) in the Terai region compared to another agro-climatic region in West Bengal, milk productivity is comparatively low as this region is mainly dominated by indigenous and non-descriptive cattle. Therefore, it is not possible for the farmers in this region to depend only on cattle rearing for their livelihood. The prominent dairy breeds found in this region were North Bengal Grey cattle, Jersey, some non-descriptive cattle etc. Some farmers were also found rearing Holstein Friesian and Sahiwal breeds. But it must say these breeds were not that much prevalent in the region.

Income from dairy production supports on average 40% of total households in the East, 32% in the North, 21% in the South and 34% in the West zone of the country (Ray et al. 2012). Several genetic (types of breeds and ability for milk secretion by individual animals) and non-genetic variables (types, quantity and quality of feeds and fodders fed, order of lactation, stage of lactation, herd size, labour use, climatic conditions etc) have a significant impact on milk production. Therefore, choosing appropriate factors to evaluate milk production is crucial. The best possible use of the numerous inputs utilised by milk producers should be a top priority. It is crucial to understand whether or not milk producers are using their inputs effectively. Planning, predicting, and developing dairy development plans in a specific area require an empirical analysis of the factors that affect milk production and the effective use of resources. Different inputs are consumed by various species of animals in varying amounts, including green fodder, dry fodder, concentrate, labour, etc., which either directly or indirectly affect milk production. It is important to know whether the resources owned by milk producers are under-utilised or over-utilised for milk production. Therefore, the knowledge of the best use of scarce resources for milk production is essential for making dairy farming a profitable enterprise. Keeping in view the above facts, the present investigation was carried out in the Terai region of West Bengal and an attempt has been made to

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know resource use efficiency in milk production in different dairy-farming systems in the area.

## Materials and Methods

### Study area and sampling

The study pertains to the state of West Bengal. A multistage random sampling design was adopted, which included selection of state, agro-climatic zone, districts, blocks, cluster of villages and respondents. Out of the 6 Agro-climatic zones in West Bengal, Terai region was selected purposively on the basis of highest livestock density (730/sq. m). Then out of four districts of that region two districts, i.e., Cooch Behar and Jalpaiguri were selected randomly. From each district three blocks (Cooch Behar – Mathabhanga II, Cooch Behar II, Sitalkhuchi and Jalpaiguri – Dhupguri, Mal, Jalpaiguri) were selected and from each block one cluster of villages was selected randomly. Thus, a total of 6 clusters of villages were selected and from each cluster of villages 30 households were selected as respondents. In all, a total of 180 respondents were selected from the region. A complete enumeration of the cluster of villages (with respect to their components of farming systems) was carried out after selecting the clusters of villages randomly. The farmers having dairy farming as one of the components in their farming system and as well as having at least two lactating animals were considered as respondents for the study. The data were collected with the help of a well-structured interview schedule by personal interview/enquiry method during the months of February-March, 2022.

### Milk production function

Milk production is a complex variable, which is influenced by several explanatory variables. In this research, production function analysis is employed to estimate resource use efficiency in milk production in the Terai region of West Bengal.

The choice of a specific functional form was based on economic and the statistical criteria and co-efficient of multiple determination ( $R^2$ ). The output and input in the above analysis is measured in monetary terms rather than their physical quantities because of the variability in the quality of feed and fodder. The Cobb-Douglas production function was the best fit for the data in the present study. Hence, Cobb-Douglas production function is used for further analysis.

The functional form of Cobb-Douglas production function is: -

$$Y = AX_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} X_5^{b_5} e^u$$

In logarithms, the function is of the following form: -

$$\log Y = \log A + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5$$

where,

|                |   |  |
|----------------|---|--|
| Y              | = | Income from milk per animal per day ( <sup>1</sup> )                   |
| X <sub>1</sub> | = | Expenditure on green fodder per animal per day ( <sup>1</sup> )        |
| X <sub>2</sub> | = | Expenditure on dry fodder per animal per day ( <sup>1</sup> )          |
| X <sub>3</sub> | = | Expenditure on concentrates per animal per day ( <sup>1</sup> )        |
| X <sub>4</sub> | = | Value of labour used per animal per day ( <sup>1</sup> )               |
| X <sub>5</sub> | = | Expenditure on veterinary services per animal per day ( <sup>1</sup> ) |

Elasticities  $b_1, b_2, b_3, \dots, b_5$  indicate the percentage change in the output due to 1% change in the particular input, while all other inputs are kept constant.

The production function was fitted to the data aggregated for all categories of animal species due to small number of observations in different farming systems. At last, production function for overall farming system was also estimated by combining all the farming systems together.

### Estimation of Marginal value product (MVP) and resource use efficiency

Marginal value product (MVP) of inputs from the most appropriate milk production function i.e., Cobb-Douglas production function is worked out as: -

$$MVP_i = b_i \frac{Y}{X_i}$$

Where,  $\bar{Y}$  and  $\bar{X}_i$  are the geometric means of Y and  $i^{\text{th}}$  input, respectively, and  $b_i$  is the estimated regression coefficients of  $i^{\text{th}}$  input.

Resource use efficiency of inputs measures whether or not the inputs are used efficiently. They are used optimally if the  $MVP_i$  of the input is equal to its unit price ( $P_i$ ), i.e.,

$$MVP_i = P_i$$

In order to examine the resource use efficiency, the MVP of various inputs is worked out for significant estimated parameters in the estimated milk production function. Any deviation of MVP of input from its unit price indicates as that the resource is not used efficiently. A higher value of MVP than its unit price implies under-utilisation and lower value of MVP than its unit price implies over-utilisation of the resource. Further, t-test is used to test the statistical significance of the difference between MVP of an input and its unit price.

$$\text{Calculated } t = \frac{MVP_{X_i} - P_{X_i}}{S.E.(MVP_{X_i})}$$

Where, SE = Standard Error of MVP. It is calculated as follows: -

$$SE(MVP_i) = SE(b_i) \frac{Y}{X_i}$$

Where,  $\bar{Y}$  and  $\bar{X}_i$  are the geometric means of Y and  $i^{th}$  input respectively and  $b_i$  is the regression coefficient of  $i^{th}$  input.

### Results and Discussion

The study area was completely enumerated and the most prevalent farming systems with dairy are identified as follows: - (Table-1)

Most prominent farming system in the study area was Dairy + Crop (D + C) farming system followed by Dairy + Crop + Goat (D + C + G) farming system.

To examine the resource use efficiency in milk production, the Cobb-Douglas production function is fitted separately for different farming systems and also for overall farming system. The estimated production function coefficients along with their standard error for each of the identified farming systems are presented in Table 2. The table reveals that 76%, 82%, 70%, 68%, 66% and 67% of variability in milk production in D, D + C, D + C + G, D + C + P, D + C + M and D + C + F farming system, respectively, can be explained by the variables included in the model, i.e., green fodder, dry fodder, concentrate, labour value and veterinary charges. The regression coefficients for green fodder are positive and significant in D, D + C + G, D + C + M and D + C + F farming system implying milk production in these farming systems could be significantly increased through efficient feeding of green

**Table 1:** Description of different identified farming systems

| Sl No.   | Name of Farming System              | Percentage of total sample | Average Land holding size (ha) | Average animal holding size (lactating animals) |
|----------|-------------------------------------|----------------------------|--------------------------------|---|
| FS – I   | Dairy (D)                           | 9.44                       | 0.28                           | 2.29  |
| FS – II  | Dairy + Crop (D +C)                 | 24.44                      | 0.48                           | 2.12  |
| FS – III | Dairy + Crop + Goat (D + C + G)     | 21.11                      | 0.32                           | 2.16  |
| FS – IV  | Dairy + Crop + Poultry (D + C + P)  | 18.33                      | 0.45                           | 2.03  |
| FS – V   | Dairy + Crop + Mushroom (D + C + M) | 18.33                      | 0.43                           | 2.15  |
| FS – VI  | Dairy + Crop + Fish (D + C + F)     | 8.33                       | 0.31                           | 2.13  |

**Table 2:** Estimated milk production function for different farming systems

| Variables  | D                   | D + C               | D + C + G           | D + C + P           | D + C + M           | D + C + F           |
|--|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| Intercept  | 6.219***<br>(1.920) | 0.881<br>(1.058)    | 1.223<br>(0.847)    | 2.190<br>(1.351)    | -0.507<br>(2.998)   | 1.135<br>(2.602)    |
| Green Fodder   | 0.724***<br>(0.210) | 0.099<br>(0.180)    | 0.288***<br>(0.106) | -0.165<br>(0.134)   | 1.216***<br>(0.288) | 0.992**<br>(0.473)  |
| Dry Fodder   | -<br>(0.236)        | 0.461**<br>(0.211)  | 0.862***<br>(0.230) | 0.696*<br>(0.398)   | 0.674<br>(0.808)    | 0.126<br>(0.461)    |
| Concentrate  | 0.058<br>(0.117)    | 0.701***<br>(0.075) | 0.124<br>(0.132)    | 0.571***<br>(0.135) | 0.327***<br>(0.158) | 0.505***<br>(0.182) |
| Labour   | -0.170<br>(0.731)   | 0.209<br>(0.243)    | 0.271<br>(0.163)    | -0.144<br>(0.214)   | 0.019<br>(0.419)    | -0.352<br>(0.411)   |
| Veterinary Charge                                    | -0.466<br>(0.274)   | 0.344<br>(0.343)    | 0.364<br>(0.189)    | 0.150<br>(0.298)    | 0.106<br>(0.332)    | 0.521<br>(0.404)    |
| Coefficient of Determination (R <sup>2</sup> ) Value | 0.76                | 0.82                | 0.70                | 0.68                | 0.66                | 0.67                |
| Total no. of Observations                            | 17                  | 44                  | 38                  | 33                  | 33                  | 15                  |

\*Significant at 10% level (P <0.1), \*\* significant at 5% level (P <0.05). \*\*\*significant at 1% level (P <0.01), Figures in the parentheses indicate the standard error of estimated parameters

fodder. Regression coefficients of dry fodder are positive and significant in D + C, D + C + G and D + C + P farming system whereas in D farming system the coefficient is negative and significant. This implies milk production can be increased by feeding more dry fodder in D + C, D + C + G and D + C + P farming system. Positive and significant coefficients of dry fodder in milk production function is also observed by Mehra et al. (2018) in the study conducted in Hilly areas of Kumaon region of Uttarakhand. The negative impact of dry fodder on milk production in D farming system implies increase in dry fodder feeding does not increase milk production. It could be due to use of poor-quality dry fodder in dairy enterprise. Coefficients of concentrate are positive and significant in D + C, D + C + P, D + C + M and D + C + F farming system. This indicates use of more concentrate in dairy in these farming systems could enhance milk production. The findings are in line with the findings of Singh et al. (2012) who reported that milk production of buffaloes could be significantly increased through the efficient feeding of

concentrates in Varanasi district of Uttar Pradesh. In another study conducted by Sharma et al. (2014), the partial regression coefficients of expenditure on concentrates and green fodder are positive and significant for all types of dairy cattle. However, the regression coefficients of labour and veterinary charges are non-significant in all farming systems implying that labour and veterinary services do not have significant impact on milk production in the area.

Marginal value product (MVP) of all the significant inputs is computed at their geometric mean level for different farming systems. The results are presented in Table 3 along with their unit prices. Since all the inputs are expressed in monetary terms in the production function, the acquisition cost of the inputs is taken as 1. The estimated marginal value product is, therefore, compared with unity to examine the resource use efficiency. The table reveals that in D, D + C, D + C + G and D + C + P farming

**Table 3:** Marginal Value Product (MVP) of inputs along with unit price in different farming systems

| Farmin<br>g<br>System<br>s   | D            |            | D + C      |             | D + C + G    |            | D + C + P  |             | D + C + M    |             | D + C + F    |             |
|------------------------------|--------------|------------|------------|-------------|--------------|------------|------------|-------------|--------------|-------------|--------------|-------------|
|                              | Green Fodder | Dry Fodder | Dry Fodder | Concentrate | Green Fodder | Dry Fodder | Dry Fodder | Concentrate | Green Fodder | Concentrate | Green Fodder | Concentrate |
| Marginal Value Product (MVP) | 1.563        | 1.646      | 0.808      | 0.962       | 0.926        | 1.748      | 1.271      | 0.847       | 3.016        | 0.474       | 1.886        | 0.527       |
| Unit Price of Input          | 1.000        | 1.000      | 1.000      | 1.000       | 1.000        | 1.000      | 1.000      | 1.000       | 1.000        | 1.000       | 1.000        | 1.000       |
| Difference                   | 0.564        | 0.647      | -0.192     | -0.038      | -0.074       | 0.748      | 0.271      | -0.153      | 2.016*       | -0.526*     | 0.886        | -0.473**    |
| Standard Error (MVP)         | 0.454        | 0.432      | 0.316      | 0.103       | 0.341        | 0.466      | 0.727      | 0.200       | 0.714        | 0.229       | 0.899        | 0.189       |
| t Value                      | 1.243        | 1.496      | -0.608     | -0.369      | -0.218       | 1.603      | 0.372      | -0.763      | 2.822        | -2.299      | 0.985        | -2.489      |

\*Significant at 5% level (P<0.05), \*\*significant at 1% level (P <0.01)

**Table 4:** Estimated milk production function for different animal species in overall farming system

| Variables                               | Indigenous Cow |                | Crossbred Cow |                |
|---|----------------|----------------|---------------|----------------|
|   | Coefficient    | Standard Error | Coefficient   | Standard Error |
| Intercept                               | 2.193**        | 0.521          | 0.891         | 1.939          |
| Green Fodder                            | 0.054          | 0.101          | 0.502*        | 0.202          |
| Dry Fodder                              | 0.507**        | 0.120          | 0.496*        | 0.253          |
| Concentrate                             | 0.486**        | 0.081          | 0.429         | 0.464          |
| Labour                                  | -0.093         | 0.105          | 0.097         | 0.195          |
| Veterinary Charge                       | 0.049          | 0.118          | 0.031         | 0.175          |
| Coefficient of Determination (R2) Value | 0.62           |                | 0.30          |                |
| Total no. of Observations               | 118            |                | 62            |                |

\*Significant at 10% level (P <0.1), \*\* significant at 5% level (P<0.05). \*\*\*significant at 1% level (P <0.01),

**Table 5:** Marginal Value Product (MVP) of inputs along with unit price for in different animal species in overall farming systems

| Particulars                  | Indigenous Cow |             | Crossbred Cow |            |
|------------------------------|----------------|-------------|---------------|------------|
|                              | Dry Fodder     | Concentrate | Green Fodder  | Dry Fodder |
| Marginal Value Product (MVP) | 0.869          | 0.712       | 1.199         | 1.022      |
| Unit Price of Input          | 1.000          | 1.000       | 1.000         | 1.000      |
| Difference                   | -0.131         | -0.288**    | 0.199         | 0.022      |
| Standard Error (MVP)         | 0.206          | 0.119       | 0.483         | 0.521      |
| t Value                      | -0.637         | -2.429      | 0.413         | 0.041      |

\*\* significant at 5% level (P<0.05)

system, the difference between the marginal value product of estimated significant inputs and unit price is non-significant. This implies that in D and D + C + G farming system, green fodder and dry fodder; and in D + C and D + C + P farming system, dry fodder and concentrate are used efficiently. Whereas, in D + C + M farming system, the difference is positive and significant for green fodder; negative and significant for concentrate. This implies that green fodder is under-utilised and concentrate is over-utilised. Similarly, Table 2 reveals that in D + C + F farming system, concentrate is over-utilised, which indicates excessive expenditure made on concentrate by the milk producers. Over-utilization could be due to a mindset of the producers that more concentrate feeding may enhance milk production.

Table 4 presents estimated regression coefficients for overall farming system in the Terai region of West Bengal. It can be seen from the table that the coefficients for dry fodder and concentrate in case of indigenous cattle; green fodder and dry fodder in the case of crossbred cattle are positive and significant. This implies that by increasing amount of feed of these inputs could enhance milk production in the study area. The coefficient of multiple determination reveals that 62% and 30% of the variability in milk production can be explained by the variables included in the model in the case of indigenous cattle and crossbred cattle, respectively. The result of the positive and significant effect of concentrate on indigenous cattle is similar to the results found in the studies conducted by Kumar et al. (2013) and Meena et al. (2019) on resource use efficiency in milk production in Haryana and Rajasthan, respectively.

The calculated marginal value product of the significant variables along with their unit price is presented in Table 5. The table reveals that in the case of crossbred cattle, green fodder and dry fodder are used efficiently. On the other hand, in case of indigenous cattle, the difference between marginal value product and unit price of dry fodder is non-significant but the difference is significant in case of concentrate. This implies that dry fodder is used efficiently for indigenous cattle. The marginal value

product of concentrate is less than its unit price indicating over-utilisation of concentrate for indigenous cattle in the study area.

### Conclusion

Based on the foregoing discussion, it can be concluded that there is wide range of variation in resource use efficiency in different types of farming systems in Terai region of West Bengal. The cost for maintaining milch animals and for milk production can be rationalized by appropriately feeding the animals. In overall farming system, it is found that dry fodder and concentrate in case of indigenous cattle; and green fodder and dry fodder in case of crossbred cattle have positive and significant influence on milk production. From the field experience, it can be said that more than 50 percent the milk producers were not fully aware of the productivity of the inputs used in the production of milk. In overall farming system, concentrate is over-utilised in case of indigenous cattle. Therefore, use of concentrate should be reduced in indigenous cattle in order to get the optimum return from milk production. Finally, it can be suggested that through extension programmes on animal husbandry like demonstrations, field visits, etc., it is necessary to inform and inspire livestock rearers about the scientific feeding of concentrate (quantity, time, proportion of mixture) in different lactation stages. It is also necessary to carry out livestock breeding programmes like upgradation of non-descriptive cattle with improved indigenous breeds and production of those cattle so that farmers can purchase the breeds of dairy animals at a reasonable price. Besides these, veterinary facility can be made available to the farmers as and when required in every village for easy accessibility.

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## References

- GoI (2019) Livestock Census, 2019. Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture and Farmers Welfare, Government of India.
- GoI (2023) Economic Survey 2022-23. Ministry of Finance, Government of India
- Kumar R, Goyal SK, Suhag KS, Singh M (2013) Resource use efficiency of bovine's milk production in Haryana. *Annals Agri-Bio Res* 18: 270-275
- Meena GL, Sharma L, Burark SS, Singh H (2019) Milk production function and resource use efficiency in Rajasthan. *J Anim Res* 9: 521-526
- Meena GL, Burark SS, Pant DC, Yogi RK; Sharma H (2012) Milk production function and resource use efficiency in Alwar district of Rajasthan. *Int J Scientific Technol Resh.* 1(8):115-119
- Ray PR, Ghatak PK, Misra AK (2012) Integrated and Sustainable Dairying: A Tool for Poverty Eradication and Rural Prosperity. *Integrated Rural Development and Management - Issues, Strategies and Policy Options* (pp.78). Agrobiose, India.
- Sharma SK, Malhotra R, Mahajan S (2014) Resource-use efficiency in milk production in Malwa region of Madhya Pradesh. *Indian J Dairy Sci* 67:531-534
- Singh SK, Agarwal SB, Chandel BS (2012) Resource use efficiency in buffalo milk production in Varanasi district of Uttar Pradesh India. *J Dairying Foods Home Sci* 31:259-263