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Estimation of milk yield gap and factors associated in local cattle of Meghalaya: Application of ANCOVA model

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ABSTRACT

The per capita availability of milk in India was 375 g/day in contrast to Meghalaya where the per capita availability was 83 g/per day as of 2017. There exists a huge yield gap in the milk yield in Meghalaya. The study was conducted in the West Khasi Hills and South West Khasi Hills districts of Meghalaya to estimate the milk yield gap and factors associated with it. A sample of 73 respondents was selected and primary data were collected. Standard method for yield gap analysis and ANCOVA model to assess the factors affecting of milk yield gap were employed. Total yield gap (TYG) turned out to be of 244.83% in Meghalaya whereas, 279.75% and 203.03% in West Khasi Hills and South West Khasi Hills districts of Meghalaya, respectively. The total yield gap (TYG) of milk in Meghalaya for local cattle was observed to be much higher as compared to national average. Study revealed that the experience in dairy farming, presence of scientific cattle shed, routine vaccination of cattle, education of household head and human labour allocated for dairy (hours) were significant factors for milk yield gap of local cow in Meghalaya. Hence, these significant factors need due care by individuals of the state who are involved in dairy business. State line department and other institutions like ICAR RC, Barapani and Central Agricultural University (Imphal), Barapani need to intervene through various awareness programmes on scientific dairy management in the state of Meghalaya

Keywords: ANCOVA, Cattle, Factor, Meghalaya, Yield gap

Emerging economies of the world including India are coping with the issues relating to poverty, hunger, malnutrition, etc. (Uchoi and Singh 2020). Milk helps in sustaining the lives of humans, especially the children and the aged ones. Out of all the livestock enterprises, dairy plays a pivot role in our national economy (Das *et al*. 2020). The by-products of milk such as butter, yoghurt, ghee, cheese, curd etc. are an integral part of the daily diet of Indian people. Local cattle milk is better source of protein, amino acids, fat, nutritionally desirable fatty acids, vitamins and minerals (Sharma *et al*. 2018).

India is bestowed with a bovine population of 192.49 million cattle, 109.85 million buffalo and 148.88 million goats (20th Livestock Census). FAO reported 1.41% increase in world milk production from 799.6 million MT (metric ton) in 2016 to 810.9 million MT in 2017 (NDDB 2016). India has become the largest milk producing country in the world with a record milk production of 146.3 million MT and 198.4 million MT in 2014-15 and 2019-20, respectively registering an annual growth of 35.61% during last six years reflecting dairy's significant role in the sustainable development of rural life in India (The Economic Times 2017). The total cattle population in Meghalaya has been estimated to be of 903.57 thousand (Livestock Census 2019). Milk production in the state has been estimated of 85 thousand MT with per capita availability of 83 g/day which was much lower than national average (375g/day) (GoI 2017).

The livestock sector couldn't take momentum in the state and traditional management practices of livestock management may be one of the reason. In Meghalaya where majority of the dairy farmers were either marginal or small who mainly keep local cows instead of improved breeds mainly due to lack of sufficient resources and knowledge. Hence, present paper is an effort to estimate the milk yield gap and to analyze the factors associated with it in regard to local cows in Meghalaya to provide straight policy implications to bridge the gap of milk yield in the state.

MATERIALS AND METHODS

Sampling design and data: The study was conducted in West Khasi Hills and South West Khasi Hills districts of Meghalaya where mix method multistage sampling technique was employed. The blocks of Mairang and Mawkyrwat from West Khasi Hills and South West Khasi Hills were selected for the study based on total cattle population. Primary data were collected using pre-tested schedule which covered a wide range of household's

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demographics and socio-economic information, milk production, disposal pattern and other activities executed by farmers with a focus on understanding the economics of milk production in the study area. After enumeration of households, a sample of 73 milk producers was selected randomly.

Yield gap analysis of milk: The analytical tool developed by the International Rice Research Institute (IRRI) and further modified by Gomez (1977) was used in the study as follows

$$\text{Total Yield Gap (TYG)} = \text{Yield Gap-1} + \text{Yield Gap-2}$$

where,

Yield Gap-1= Experiment Station Yield (Yr) – Potential Farm Yield (Yp)

Yield Gap-2 = Potential Farm Yield (Yp) – Actual Farm Yield (Yf)

The yield gap percentage was calculated using the following formula:

$$\text{Yield gap (\%)} = (\text{Yield gap/actual farm yield}) \times 100$$

Application of ANCOVA Model: The factors contributing to yield gap were determined by the following ANCOVA model:

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4D_1 + \beta_5D_2 + \beta_6D_3 + \beta_7D_4 + \beta_8D_5 + \beta_9D_6 + \beta_{10}D_7 + \mu$$

where, Y, Yield gap (Potential farm yield-actual farm yield); β_i, Parameters to be estimated (i= 0, 1, 2…, n); X_1, Experience in dairy farming (Years); X_2, Distance from farmers' farm to research station (km); X_3, Human labour allocated/head of milch animal/day (hours); D_1, Educational level of the family-head (dummy); D_2, Education level of the person who is involved in dairy activities (dummy); D_3, Economic status of dairy farmers (economically sound-1, otherwise-0); D_4, Contact with extension personnel (yes-1, no-0); D_5, Scientific cattle shed (yes-1, no-0); D_6 ,Vaccination (yes-1, no-0); D_7, Green fodder availability (Easily available-1, otherwise-0) and μ, error term.

RESULTS AND DISCUSSION

All the sampled households possessed in-milk and not pregnant cattle in the entire study area while 86.30% of households maintained in-milk and pregnant cattle across the districts which constitute of 94.6% and 77.8% of milk producer from WKH and SWKH, respectively. Similarly, dry and pregnant cattle possessed by 38.4% of household in the sample which contributed of 37.8% and 38.9% by the WKH and SWKH, respectively. Table 1 revealed that the milk producers of WKH were having comparatively more number of cattle of different categories.

The average number of cattle in Standard Animal Units (SAU) owned by the selected households is presented in Table 2. The average (mean) cattle in-milk and not pregnant was 3.03 SAU (3.38 SAU in WKH and 2.67 SAU in SWKH) whereas; for in-milk and pregnant cattle, it was 1.08 SAU with WKH (1.32 SAU) and SWKH (0.83 SAU). In the category of dry and pregnant cattle, it was to be of 0.81 SAU overall, with 0.84 SAU and 0.78 SAU of WKH and SWKH, respectively. In case of pregnant heifer, standard animal unit was observed only in WKH, although it was very low (0.04 SAU). Contrary to it, similar study of Kemboi *et al*. 2021 in Meghalaya indicated that the average number of cattle per household was 9.38 in standard animal units.

Table 1. Percentage of households reporting ownership of cattle

Category of animal		WKH	SWKH	Overall
In-milk and not pregnant		100.0	100.0	100.0
In-milk and pregnant		94.6	77.8	86.3
Dry and pregnant		56.8	41.7	49.3
Dry and not pregnant		37.8	38.9	38.4
Pregnant heifer		8.1	–	4.1
Calves <1 year	Male	97.3	88.9	93.2
	Female	91.9	97.2	94.5
Calves >1 year	Male	62.2	19.4	41.1
	Female	51.4	22.2	37.0
Adult male		64.9	80.6	72.6

Source: Field survey data calculation.

Hence, standard animal unit analysis was an eye opener for the line department of the state where SAUs of different categories of the animals need to be enhanced through different scientific interventions.

Yield gap: Yield gaps (YG-1 and YG-2) in milk production in districts of WKH and SWKH of Meghalaya were estimated for local cow (Table 3). These yield gaps refer to the yield differentials between the research station yield, potential farm yield and the actual farm yield. The research station yield data for local cows were collected from ICAR-NEH, Barapani. Table 3 revealed that the research station yield for local cow was 3 litres per day (L/day) for both the districts which indicates the maximum milk yield that existed per milch local cattle in the study area. It was found that the potential farm yield for the study area was 1.29 L per day for local cow which was comparatively highly lower than rest of the country, bridging the Yield Gap-1 of 196.55% which was exceptionally higher and was very tough. In WKH, the potential farm yield was 1.01 L/day raising the Yield Gap-I to 251.89% while in SWKH, the potential farm yield was found to be 1.36 L/day, raising the Yield Gap-I to around 165.66%.

The actual farm yield for the study area was 0.87 L/day, which makes the Yield Gap-2 to 48.28%. In WKH, actual farm yield was observed to be 0.79 L/day to make the YG-2 of 27.85% whereas, in SWKH, the actual farm yield was 0.99 L/day raising the YG-2 to 37.37%. These results were in conformity with Kemboi *et al*. 2021 in which they found total yield gap (91.06%) per day, composed of (11.76%) per day of yield gap-1 and (79.30%) per day of yield gap-2 and further explained that the top performing farms were achieving a production

Table 2. Average number of cattle (in SAU) owned by the selected households

Category of animal	WKH			SWKH			Overall		
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
In-milk and not pregnant	3.38	7.00	1.00	2.67	7.00	1.00	3.03	7.00	1.00
In-milk and pregnant	1.32	3.00	0.00	0.83	3.00	0.00	1.08	3.00	0.00
Dry and pregnant	0.84	3.00	0.00	0.78	5.00	0.00	0.81	5.00	0.00
Dry and not pregnant	0.62	4.00	0.00	1.03	10.00	0.00	0.82	10.00	0.00
Dry and unfit for breeding	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Not calved even once	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pregnant heifer	0.08	0.98	0.00	0.00	0.00	0.00	0.04	0.98	0.00
Calves <1 year (male)	1.78	4.26	0.00	1.03	2.84	0.00	1.41	4.26	0.00
Calves <1 year (female)	1.77	4.10	0.00	1.78	4.92	0.00	1.77	4.92	0.00
Calves >1 year (male)	0.52	1.42	0.00	0.22	1.42	0.00	0.37	1.42	0.00
Calves >1 year (female)	0.6	1.64	0.00	0.30	2.46	0.00	0.45	2.46	0.00
Adult male	1.05	3.33	0.00	1.91	4.44	0.00	1.47	4.44	0.00
Total	11.97	28.67	3.42	10.53	27.63	1.71	11.26	28.67	1.71

Note: Max, Maximum; Min, Minimum; *Source:* Field survey data calculation.

Table 3. Estimation of yield gap in milk production

Particular	WKH	SWKH	Meghalaya
Research station yield (L/day/animal)	3.00	3.00	3.00
Potential farm yield (L/day/animal)	1.01	1.36	1.29
Actual farm yield (L/day/animal)	0.79	0.99	0.87
YG-I (1-2)	1.99	1.64	1.71
(%)	(251.89)	(165.66)	(196.55)
YG-II (2-3)	0.22	0.37	0.42
(%)	(27.85)	(37.37)	(48.28)
Total Yield Gap (YG-I + YG-II)	2.21	2.01	2.13
(%)	(279.75)	(203.03)	(244.83)

WKH, West Khasi Hills; SWKH, South-West Khasi Hills; L, Litre(s).

Source: Field survey data calculation.

level not dissimilar to that obtained on the research stations, but many were doing far less well. After computing and summing up these, the total yield gap turned out to be 244.83% in the state of Meghalaya while it was 279.75% and 203.03% in districts of WKH and SWKH, respectively. The yield gaps, mainly YG-I and total yield gap (TYG) turned out higher possibly due to the fact that a huge majority of farmers lack adequate knowledge and resources to maintain a local cow as compared to the ones in research station. Another possible reason for the huge yield gap may be due to the dietary habits of the people who prefer meat over milk and rarely includes milk and its products in their meals.

Factors affecting yield gap: It was apparent (Table 4) that the explanatory variables included in the regression function described around 80.20% of variation in the dependent variable of yield gap in the entire study area (59.9% in WKH and 90.4% in SWKH). It was found that experience in dairy farming ($P<0.01$), presence of scientific cattle shed ($P<0.01$), vaccination ($P<0.01$), education of household head ($P<0.05$) and human days allocated (hours) for dairy ($P<0.10$) has a significant effect on yield gap of local cows in the state of Meghalaya. An increase in one unit year in experience can cut down the yield gap by about 0.031 Litre (0.015 L in WKH and 0.032 L in SWKH). Presence of scientific cattle shed can narrow the yield gap by around 0.099 L in Meghalaya (0.037 L in WKH and 0.085 L in SWKH). Regular vaccination to cattle prevent from diseases like FMD, Mastitis can cut down the yield gap by around 0.067 L comprising of 0.052 L in WKH and 0.071 L in SWKH. It was also found that if a household head is literate, the yield gap can be minimized by 0.067 L. In Meghalaya, economic status of the household had shown significant effect ($P<0.10$) on yield gap in district of SWKH and it can narrow down the gap by 0.051 L. An increase in 1 h of daily labour allocated for dairy will lead to cut down the yield gap by 0.076 L.

The SAUs of different categories of the animals in the state has been estimated to be very low and which needs to be enhanced through different scientific interventions. The total yield gap (TYG) of milk in Meghalaya for local cattle was observed to be much higher as compared to national average. Among the milk yield gaps; the yield gap-1 (YG-I) was larger than yield gap-2 (YG-II) while most research findings say otherwise and it was an exceptional case for further taking into account for research and development on this regard.

Overall, the YG-1 and YG-2 was estimated of 196.55% and 48.28% of the actual farm yield, respectively which collectively was TYG observed to be of 244.83%. In West Khasi Hills, the YG-1, YG-2 and TYG were 251.89%, 27.85% and 279.75%, respectively while in South-West Khasi Hills, the YG-1, YG-2 and TYG turned out to be 165.66%, 37.37% and 203.03 %, respectively. It indicates

Table 4. Estimated coefficient of factors affecting yield gap in milk production

Particular	WKH		SWKH		Meghalaya	
	ß	P value	ß	P value	B	P value
Constant	2.133***	0	2.518***	0	2.360***	0
Experience in dairy farming	–0.015**	0.02	–0.032***	0	–0.031***	0
Education of the household head	–0.064	0.12	0.001	0.382	–0.067**	0.021
Education of the person involved in dairy	–0.03	0.496	–0.0001	0.499	–0.01	0.765
Economic status	–0.007	0.384	–0.051*	0.098	–0.03	0.231
Scientific cattle shed	–0.037**	0.028	–0.085**	0.014	–0.099***	0.001
Distance of farmers farm to research station	0.005	0.192	–0.005	0.272	0.002	0.572
Contact with extension personnel	0.047	0.112	–0.034	0.284	–0.013	0.624
Green fodder availability	0.013	0.677	0.038	0.259	0.032	0.232
Human days allocated for dairy	–0.03	0.555	–0.021	0.677	–0.076*	0.057
Vaccination	–0.052*	0.056	–0.071**	0.045	–0.067***	0.007
R^2	0.599		0.904		0.802	
No. of observations	37		36		73	

Note: ***, ** and * indicate P< 0.01, P<0.05 and P<0.10, respectively. *Source:* Field survey data calculation

that if all the constraints regarding milk production were addressed duly and measures taken, milk yield of local cow in Meghalaya could be increased by about 245%.

Regression analysis was performed using ANCOVA model to detect the factors affecting the milk yield gap. It revealed that experience in dairy farming, presence of scientific cattle shed, routine vaccination of cattle, education of household head and human days allocated (hours) for dairy had a significant effect on the milk yield gap of local cows in Meghalaya. The study also reported that one more year of experience in the field of dairy can narrow the milk yield gap by around 0.031 L. The findings also suggest farmers to construct scientific cattle shed as presence of it may cut down the milk yield gap by 0.099 L (0.037 L in WKH and 0.085 L in SWKH). Vaccination done regularly and timely may reduce the yield gap by 0.067 L (0.052 L in WKH and 0.071 L in SWKH). The yield gap can be minimized by 0.067 L when a household head is literate while it can be narrowed in SWKH by 0.051 L when a household head is economically sound. Increase in 1 daily hour allocated for dairy animals in Meghalaya will help to reduce the yield gap by 0.076 L.

The study suggests that SAU of individual household need to increase from present level through various breed development programmes of State and Central governments by involving farmers with participatory approach. The factors identified and found significant in milk yield gap need to be given due care by the individual milk producers and line department to boost-up the milk production of last milk producer located in remotely located village of the state of Meghalaya.

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