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THE EFFECT OF GROWTH IN DEMAND FOR MILK ON THE DEMAND FOR CONCENTRATE FEEDS, INDIA, 1951-76

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BRUNO DE PONTEVES

INTRODUCTION

GROWTH in demand for milk in India will be rapid as population grows and a high income elasticity of demand for milk gives substantial effect to rising per capita incomes. The high nutritional value of milk attaches special importance to meeting increased demand for milk with increased supply. This is particularly truesince cultural factors favour milk over other forms of animal protein.

Agricultural labour and livestock feed are the principal production inputs of increased milk production. Since providing adequate, productive employment for a growing rural population is a primary problem of Indian economic development, relatively large labour requirements tend to favour increased milk production over many other forms of economic activity. It follows that under Indian conditions the critical input for increased milk production is livestock feed, particularly in concentrate forms. In India feed costs comprise up to three-quarters of the total cost of producing milk and concentrate feeds in turn represent a substantial proportion of total feed cost.

This paper is principally concerned with estimating current utilization of concentrate feeds for milk production and from this estimating the concentrate feed requirements to meet projected demand for milk for domestic consumption. Estimates of the present volume of milk production and projections of the demand for milk will first be presented, followed by estimate of current utilization of concentrate feeds and projections to 1975 of the derived demand for concentrate feeds. The data available for these estimates and projections are scant, requiring a number of major assumptions. The paper serves therefore largely to indicate

the implications of a number of logical assumptions, some of the data needs far more accurate appraisal of concentrate needs, the magnitude of the problem, and an analytical framework appropriate to handling better data as it becomes available.

Milk Production, 1955-56

The base used in this paper for projections of the demand for milk is production in 1955-56 as estimated by the Directorate of Marketing and Inspection. Their estimate for 1955-56 is based on the product of separate estimates of (a) the total number of animals in milk on the date of the livestock census and (b) the average daily milk yield per animal in milk.[1]

Estimate of number of animals in milk may be biased by a number of factors including the date of the reference period for the enumeration. For example, as compared to the Directorate's estimate, Chowdhary and Narang arrive at a nearly 25 per cent higher estimate of milk production in 1956 by simply using a different set of assumptions, which are quite plausible, concerning the average calving interval.[2] Likewise, the Directorate's estimate of milk production in 1951-52 may be substantially biased as compared to the 1955-56 estimate due to a different reference period which in turn provides a different average calving interval.

The variable and subjective method of estimating milk production per animal also introduces considerable uncertainty concerning the reliability of the estimates and makes it particularly difficult to estimate the trend in production from production data for successive years.[3] After reviewing the Directorate's estimates of production for 1951-52 and 1955-56 and the set of estimates by Chowdhary and Narang it was decided to use the Directorate's 1955-56 estimate as a base. The Directorate's estimate states a total of 19.3 million long tons of milk produced in 1955-56, 56 per cent from buffaloes, 41 per cent from cows and 3 per cent from goats. This study will concern itself entirely with the production from buffaloes and cows. The yield per animal of the total population of females implicit in the Directorate's formula is 382 pounds of milk per cow and 1,100 pounds of milk per buffalo.

For the purposes of this study milk production in India is divided into three distinct production situations. These situations differ significantly in regard to both demand and supply conditions and the relative importance of each of the three situations is likely to change over time.

Urban producers are located directly in urban areas and carry on dry-lot operations for which all or nearly all of both concentrate feeds and roughage is purchased from rural areas. The resultant high cost of roughages and the high price for milk result in heavy rates of feeding of concentrate feeds and high milk production per animal.

1. R. K. Chowdhary and K. L. Narang, "Milk Production—Its Technique of Estimation," *Agricultural Situation in India*, Vol. XVII, No. 2, May, 1962, p. 124.

2. *Ibid.*

3. See for example: R. T. Mirchandani and S. Jayaraman, "Trend of Milk Production in India," *Agricultural Situation in India*, Vol. XIV, No. 7, October, 1959.

Nearby Village producers lie in rural areas where roughages tend to be cheaper, but produce for the urban market with its relatively favourable milk price. They will normally be located within 15 miles of urban markets although special transport facilities allow this radius to expand considerably. Price relationships cause these producers to feed concentrates less heavily and achieve lower yields per animal as compared with the urban producers.

Distant Village producers produce for the rural market and are in large part out of the existing marketing range for urban markets. The low effective price of milk and other factors cause them to feed concentrate feeds at very low rates and to achieve low levels of milk production per animal.

Estimates have been made by Banerjee of the supply of milk to cities of over 50,000 population and by FAO of the proportion of urban milk supplies coming from rural areas.[4] From these estimates judgements were made as to the proportion of total milk production which falls into the three types of production situations described (Table I).

TABLE I—ESTIMATED ORIGIN OF MILK PRODUCTION, INDIA, 1956

Production area	Milk Production	
	Millions of long tons	Per cent
Urban ..	3·5	18
Nearby Village ..	1·9	10
Distant Village ..	13·9	72
Total	19·3	100

CHANGE IN THE DEMAND FOR MILK, 1951-1975

The rate of change in demand for milk is estimated from estimates of the rate of change in population, rate of change in per capita income and the income elasticity of demand for milk. Uncertainty exists concerning the magnitude of each of these statistics. For the purposes of this study population growth is taken as estimated by the Central Statistical Organization and reported in the Third Five-Year Plan; per capita income growth is taken from the Planning Commission estimates of total income growth and population growth as reported in the Third-Five Year Plan[5]; and the income elasticity of demand for milk is taken as a simple average of the rural and urban elasticities computed for rounds two through ten of the National Sample Survey, and converted from expenditure elasticity to income elasticity. In the conversion from expenditure elasticity to income elasticity, the elasticity of expenditure with respect to income was assumed to be 0.84 as computed by the NCAER.[6] The income elasticity so calculated

4. G. C. Banerjee, "Role of Various City Milk Schemes in the Development of Dairy Industry in India," *Indian Dairyman*, Vol. XI, No. 5, May, 1959, p. 122 ; and Food and Agriculture Organization, Committee on Commodity Problems, 34th Session, Dairy Problems—Policies and Programs in India, United Nations, Rome, February, 1961, p. 1.

5. Third Five-Year Plan, Planning Commission, Government of India, New Delhi, 1961, p. 28.

6. NCAER, Long-Term Supply and Demand for Selected Dairy Products in India, 1960-61 to 1975-76, New Delhi, August, 1961, p. 16.

is 1.52. There is no significant difference shown in NSS data between the urban and rural elasticities. The variation in elasticities as computed from the various rounds is small.

With these assumptions and using the Directorate's estimate of milk production in 1955-56 as a base, projections of the demand for milk for five-year intervals to 1975-76 and extrapolation back to 1950-51 are made as follows : (in millions of long tons).

1950-51	1955-56	1960-61	1965-66	1970-71	1975-76
15.3	19·3	23·4	33.3	47.6	68.6

From 1955-56 to 1975-76 the demand for milk is assumed to increase by more than 3½ times. By the same procedures the demand for milk in 1950-51 is estimated to have been 80 per cent of the demand in 1955-56.

It is interesting to note that the Directorate's estimate of production for 1950-51 is over 88 per cent of the 1955-56 level. This significant difference indicates clearly the uncertainty which surrounds estimates of milk production and consumption in India. The discrepancy may arise because :

1. The 1951 estimate by the Directorate is a substantial over-estimate. However, adjustment of the 1951-52 data for difference in reference period and calving interval would raise the 1951-52 estimate of production closer to the 1955-56 level.

2. The 1955-56 estimate is a substantial under-estimate.

3. Some combination of the above.

4. The rate of change in demand during the 1951-56 period as estimated in this work is too great. This means that a mis-estimate has been made in regard to either (a) population increase, (b) per capita income increase, (c) income elasticity or (d) some combination of these. All three of the assumptions made on these matters are generally accepted as reasonable.

5. The price of milk has increased relative to the prices of other commodities. Since the price elasticity of demand is most likely less than —1.5, it would have taken a relatively small increase in the relative price of milk to equate the estimated increase in demand with the Directorate's estimate of the increase in production. Assuming a price elasticity of demand for milk of —1.5, a price increase of about 7½ per cent would have equated these estimates. If the price elasticity is somewhat less than —1.5, which seems likely, than an even smaller price increase would have accomplished this equation. Because of the problem of standardization in milk, it would be very difficult to test a hypothesis in regard to the trend in milk prices in the 1951-56 period.[7]

The preceding comparisons serve to emphasis the uncertainty which surrounds current estimates of milk production and consumption in India. It is difficult to check measured changes in production against estimates of change

7. It is reported in a survey in Madras that 65 to 75 per cent of the milk marketed had been adulterated. Presumably the adulteration percentage varies from time to time. FAO, Dairy Problems, *Op. cit.*, p. 9.

in demand, due to the lack of detailed price information. Faulty demand estimates are particularly likely to arise from mis-estimates of changes in per capita income, although even the estimates of population change and income elasticities could err significantly. In regard to production, the method of estimating production per animal may be subject to large error relative to the magnitude of changes in production which occur over periods of five or ten years. In addition the methods of estimating production per animal are probably particularly poorly adapted to measuring increases which occur as urban market areas expand and the higher feeding rates and production per animal characteristic of Nearby Villages cover a broader and broader area.

Concentrate Feed Use, 1955-56

Concentrate feed consumption by milk animals in 1955-56 is estimated from estimates of the total volume of milk production and the average relationship between milk output and concentrate feed use. Since feeding practices and input-output ratios differ considerably among major types of milk production situations in India, a separate estimate is made for each of the three major milk production sectors delineated. To provide a basis for these estimates a large number of empirical studies of dairy farming were examined. Unfortunately relatively few studies provide physical input-output data. A potential bias arises because the available studies were concentrated in the more intensive dairy tracts of north-western India, where feeding rates and milk production per animal are higher than average for India.

To improve the basis for judgement the means from 13 available studies reporting physical data were used as separate observations from which the relationship between concentrate feed input and milk output was calculated. The data and sources are shown in Table II.

Linear and quadratic equations were fitted to the *averaged* data and provided roughly similar r^2's at .74 and .76 respectively. Since the quadratic equation is supported by better economic logic and is more consistent with results from other studies of this type, it was chosen as most suitable for use in later calculations. Using the best fitting quadratic equation ($Y = 944 + 5.48x - 0.00325x^2$), the milk yield per year, the average milk feed production ratio and the marginal productivity of concentrate feed were computed for various rates of feeding (Table III).

The relationship depicted should probably not be interpreted as a farm management production function. Important distortion of relationship may arise from three separate sources.

Firstly, the observations from the Urban, Nearby Village and Distant Village situations may represent points on three or more quite different production functions. It is difficult to judge the extent to which this is the case since the three sets of data do not overlap appreciably. It is of course logical that the urban dairies should buy better than average cows, since they are producing under high cost and high price conditions in which the comparative advantage would lie with the more productive animals. If in fact several different production functions

TABLE II—CHARACTERISTICS OF DATA SOURCES CONCERNING CONCENTRATE FEED MILK OUTPUT RELATIONSHIPS, INDIA, 1954-60

Place	Year	Type of producer	Type of cattle	Concentrate feed lbs / day/ animal	Milk production lbs./year
Dist. of Amritsar (Punjab)[a]	1954-55	Distant village	Cows & Buffalo	0·69	1152
Meerut (U. P.)[b]	1954-55	Distant village	Buffalo	0·92	1531
Dist. of Ferozepur[a]	1954-55	Distant village	Cows & Buffalo	2·27	1851
Meerut (U.P.)[c]	1955	Nearby village	Buffalo	2·71	2643
Gwalior (M.P.)[d]	1956	Nearby village	Buffalo	2·82	1991
New Delhi[e]	1959-60	Nearby village	Buffalo	3·28	1782
Aligarh (U.P.)[f]	1959-60	Nearby village	Buffalo	5·33	2993
Gwalior (M. P.)[d]	1956	Urban or Res. Inst.	Buffalo	3·39	2650
Meerut (U.P.)[g]	1955	Urban or Res. Inst.	Buffalo	3·43	2723
Haringhata (W. Bengal)[h]	—	Urban or Res. Inst.	Buffalo	4·49	2800
New Delhi[h]	—	Urban or Res. Inst.	Buffalo	5·36	2800
Bharari (U.P.)[h]	—	Urban or Res. Inst.	Buffalo	5·80	3100
Poona (Bombay)[i]	1957	Urban or Res. Inst.	Buffalo	8·34	3361

Sources : *a* Government of India, Ministry of Food and Agriculture, Studies in Economics of Farm Management in Punjab, Albion Press, 1954-55 ;

b Government of India, Directorate of Economics and Statistics, Studies in Economics of Farm Management in Uttar Pradesh, Albion Press, 1958 ;

c S. S. Bhati, Cost Studies for Milk Production in the Eastern Part of Haryana Tract in the District of Meerut, U. P., Unpublished Master of Science thesis (Agra University, 1955);

d Indapurkar, To Work Out the Most Economical Unit for Production of Milk in Gwalior Town and Suburbs, Unpublished Master of Science thesis (Agra University, 1956);

e Unpublished data from the Indian Agricultural Research Institute ;

f S. C. Maheshwari, Milk Production in Rural Areas (with reference to Aligarh District of U.P.), Unpublished Master of Science thesis (Agra University, 1961) ;

g A. B. Nabar, "Comparative Efficiency of Cow and Buffalo as Producers of Milk," Balwant Vidyapeeth, Bichpuri (Agra), Vol. I, January, 1959 ;

h R. O. Whyte : Grassland and Fodder Resources of India, Indian Council of Agricultural Research, New Delhi, 1957 ;

i S. G. Sapre, "A Note on the Cost of Production of Milk in Poona," *Artha Vijnana,* December 1959, p. 315.

TABLE III—RELATIONSHIP BETWEEN CONCENTRATES FED AND MILK YIELDS, INDIA, 1954-60

Production per animal	Pounds of concentrate fed per animal per day							
	0·5	1·0	2·0	3·0	4·0	5·0	6·0	7·0
Milk yield per year (pounds)	1,210	1,460	1,910	2,296	2,616	2,872	3,062	3,188
Overall average productivity (total milk in pounds/total concentrate in pounds) ..	6·6	4·0	2·6	2·1	1·8	1·6	1·4	1·2
Marginal productivity (pounds of milk per pound of concentrate)	1·41	1·32	1·13	0·97	0·79	0·64	0·43	0·25

Source : See text.

are represented it seems likely that the production functions for the Distant Village animals and to a lesser extent the Nearby Village animals turn down at lower levels of concentrate feed input than is the case for the animals in the Urban dairies. The village functions might also be offset downwards providing lower response

at lower levels of feed input. However inspection of the data provides no basis for the latter supposition.

Secondly, the feeding value of the concentrate feeds used may be related to the level of concentrate feeding. It is quite possible that those producers feeding at higher rates are also feeding concentrates with higher feeding value per pound. This would tend to give the function a steeper slope than if the quality were held constant.

Thirdly, it is possible that roughage quality is related to the quantity of concentrate fed. Producers who feed concentrates heavily may also feed higher quality roughage as well. This too would bias the function up and to the right. This possibility and the preceding one may be particularly likely in the Indian situation in which different levels of feeding are associated with sharply contrasting production situations.

However, the factors which require caution in the use of the relationship described between feed input and milk output for farm management purposes may cause little reduction in its efficiency for aggregate projection purposes. This will be the case if any biasing relationships continue unchanged during the period for which the projections are made. This in fact appears likely in the case under study.

On the basis of the functional relationship between concentrate feed input and milk output and data for milk production in other areas, assumptions have been made concerning the average relationship between concentrate feed use and milk output for each of the three milk production sectors. From these assumptions and estimates of total milk production in each sector an estimate has been made of the aggregate quantity of concentrate feed required for the estimated level of milk production in 1955-56 (Table IV).

TABLE IV—ESTIMATED CONSUMPTION OF CONCENTRATE FEEDS BY MILK ANIMALS, INDIA, 1955-56

Sector	Milk production(*a*) (000,000 long tons)	Pounds of milk per pound of concentrate (*b*)	Concentrate feed use (000,000 long tons)
Urban	3·5	1·5	2·3
Nearby Village	1·9	2·7	0·7
Distant Village	13·9	6·7	2·1
Total ..	19·3	3·8	5·1

(*a*) From Table I.
(*b*) See text for the basis of these assumptions.

The assumption of 6.7 pounds of milk per pound of concentrate for Distant Villages implies an average rate of feeding of about 0.5 pounds of concentrate per day and milk production of about 1,200 pounds per year per animal. This is lower than any of the Distant Village observations included in Table II. However, it is probably more representative of the all-India situation than the observations in Table II which all fall in intensive dairy tracts. It represents an average production per animal well above the all-India average, but again it may be more representative of the situation for the animals which are actually kept for milk production.

The assumption of 2.7 pounds of milk per pound of concentrate for Nearby Villages falls at the lower end of the range depicted for such villages in Table II. This too is probably more representative of the all-India situation than the data in that Table.

The assumption of 1.5 pounds of milk per pound of concentrate for the urban dairies lies above the median level in regard to pounds of concentrate fed per day for the urban dairies shown in Table II. The choice of this higher level reflects the substantial importance of the urban dairies in the large cities where economic forces argue for high feeding rates.

On the basis of these assumptions it is estimated that in 1956 over 5 million tons of concentrates were used for milk production alone. This is an amount equal to over seven per cent of total foodgrains production in 1955-56. Nearly half of the total concentrate fed was used in urban areas to produce less than 20 per cent of the total milk supply.

The available aggregate estimates of concentrates supplied to livestock suggest much lower usage than the above estimates which are based on input-output data. A set of estimates of aggregate consumption of concentrate feed by livestock has been compiled from a number of sources and is set forth in Table V. Of the total of 9 million tons so estimated, 6.5 million tons, or a little over three-quarters comes from by-product sources. The remainder is comprised of foodgrains. In general, in these estimates, only the high feeding value by-product feeds are counted as concentrate feeds. They are also counted as by-product feeds only if they are in a form not likely to be usable for direct human consumption.

The principal consumers of concentrate feeds are milk animals and work-stock. The Ministry of Agriculture Farm Management studies and other sources indicate that in general the cost per head of maintenance of work animals is roughly similar in total and in composition to that of milk animals.

The total number of work animals for 1956 was estimated at 71 million. If we arbitrarily reduce that by ten per cent to 64 million and assume that those animals consume an average of 0.5 pounds of concentrate per day (the same as the average for the Distant Village milk animals) then it is estimated that 5.3 million tons of concentrate feeds is consumed by work animals.

The estimate of 5.3 million tons of concentrates fed to workstock allows about 33 pounds of concentrate for workstock per acre of gross area sown. 71 million head of workstock allowed, in 1956, for a little over 10 acres of gross sown area per pair of workstock.

The feeding rate assumed for workstock appears low.[8] Nevertheless, the estimate of 5.3 million tons of concentrates to workstock is somewhat higher than the 4.9 million tons of concentrates estimated by NCAER for all animal consumption except bovines.[9] Thus, although it was initially derived in a rela-

8. Whyte: *Op. cit.*; Government of India, Farm Management Studies, *Op. cit.*; and P. E. Lander: Feeding of Farm Animals in India, Indian Council of Agricultural Research, New Delhi, 1949.

9. NCAER, Dairy Products, p. 54.

TABLE V—AGGREGATE ESTIMATE OF CONSUMPTION OF CONCENTRATE FEED BY LIVESTOCK, INDIA, 1955-56

Available for animal consumption	Millions of long tons	Per cent
Bran (*a*)	2·7	30
Oil cakes (*b*)	1·3	14
Cotton seed (*c*)	1·3	14
Chuni (*d*)	1·2	14
Foodgrains (*e*)	2·5	28
Total	9·0	100

(*a*) Bran availability is estimated as 15 per cent of wheat production and 5 per cent of rice production, providing 1·36 million tons of rice bran and 1·29 million tons of wheat bran. See R. Dayal, "Food Planning, Cereals vs. Milk," *Agricultural Situation in India*, May, 1956, p. 1328 and NCAER, Dairy Products, p. 39.

(*b*) Oil cake production is estimated at 2 million tons, from which 1.30 million tons is used for livestock feed and 0·70 million tons for manurial purposes. See NCAER, *Ibid.*, and FAO, Dairy Problems.

(*c*) Estimated from FAO, Dairy Problems.

(*d*) Estimate in FAO, Dairy Problems. These comprise husks from other grain and pulses having a nutritive value approximately the same as that of bran.

(*e*) The National Income Committee estimated that 2·4 per cent of the value of foodgrains production is fed to livestock. R. S. Srivastava: Agricultural Marketing in India and Abroad, Bombay, 1960, p. 48. This estimate is based on marketing surveys. Because the grains fed to livestock are presumably of lower value per ton, a somewhat higher proportion of the tonnage is assumed to have been fed to livestock. On the basis of relative wholesale prices of rice and wheat as compared to other grains an upward adjustment was made to 3·6 per cent of total tonnage. Thus it is assumed that in the base year of 1956, 2·50 million tons foodgrains were fed to livestock.

tively artificial manner, the estimate of 5.3 million tons of concentrates for work animals does not seem unreasonable. In contrast, the residual estimate of 3.7 million tons of concentrates supplied to milk animals is less than three-quarters of the 5.1 million tons previously estimated from assumed aggregate milk production and average feed productivities.

In view of these data it is likely that either (*a*) milk production is considerably less than that estimated by the Directorate, (*b*) concentrate consumption is considerably more than that estimated from aggregate data, or (*c*) the concentrate-milk relationships depicted in Table III are unrealistic. The relative support available for each of these sets of figures, suggests that the concentrate estimate is low.

If we assume the calculated estimate of concentrate use for milk animals of 5.1 million tons; assume another 5.3 million tons for workstock; accept the estimate that by-products provide 6.5 million tons of concentrate, then it appears that a total of 3.9 million tons are supplied from foodgrains. This compares with an estimate of 2.5 million tons derived from the estimate of the National Income Committee.

These estimates are admittedly very rough. Grain feeding in Distant Villages may be over-stated as may the allowance for workstock. On the other hand, a clear counter-balancing factor is the lack of specific concentrate allowance for raising young stock and for other types of livestock.

PROJECTION OF THE DEMAND FOR CONCENTRATES

Estimates of future concentrate feed requirements for milk production depends on the future demand for milk, the extent to which the demand will be met by increased domestic production and the relationship between concentrate feed input and milk output. It will be difficult to meet the growth in urban demand for milk from increased domestic production because major difficulties in expanding marketing and processing facilities are superimposed on problems of expanding production. There is very little basis for an estimate of the extent to which production in Urban and Nearby Village areas can be expanded and what the conditions of such expansion may be. Neither is there information to indicate the extent to which the serious marketing and processing problems may be solved.

The following estimates of concentrate feed requirements assume that the marketing and production problems can be solved and that the projected growth in demand will be matched by increased domestic production. These calculations will thus show the concentrate feed requirements if such an expansion in production is achieved. Alternative estimates are based on three different assumptions concerning the extent to which increased production will come from each of the three production sectors delineated. The three estimates are summarized in Table VIII.

Since all three estimates are based on existing feeding practices, no account is taken of future substitution of high quality roughages, such as berseem and lucerne, for concentrates. Since under Indian conditions such roughages compete with foodgrains for essentially the same land resource, savings in foodgrains from the use of high quality roughage will be compensated at least in part by diversion of production resources away from foodgrains and towards such roughage. Nevertheless significant increase in resource efficiency can probably be achieved through use of high quality roughage and these estimates will accordingly overstate the drain on productive resources for milk production.

Estimate I

Estimate I is based on the assumption that the existing average feed-milk production ratio will not change as production increases. The ratio assumed is that of 3.8 pounds of milk per pound of concentrate as shown in Table IV. Since output-input relationships vary considerably among the different milk production sectors this assumption postulates a proportionate expansion of each of the sectors. It is consistent with the assumption that (a) milk animal numbers in each sector will increase proportionately to the increase in production with no change in feeding practices or quality of cows, or (b) that increased production is achieved by heavier rates of feeding and hence declining marginal product which is just balanced by increased productivity due to a shifting of the production function as a result of improved breeding and production practices, or (c) some combination of (a) and (b).

In appraising the implicit assumptions behind Estimate I, it is important to remember that a large proportion of existing production in India occurs in the Distant Village situation, at very low levels of feed input and milk output. It is quite possible that in the Distant Village situation the pressure of other costs

besides concentrate feed costs will prevent expansion of cow numbers in proportion to the growth in demand for milk. In addition it is unlikely that the huge increase in feeding efficiency can be achieved which is implicit in maintaining a very low feed input-milk output ratio in the face of considerably higher rates of feeding. Further a more than proportionate increase in demand is likely to occur in the urban areas which are now served by the production sectors with relatively low feeding efficiency. Thus Estimate I probably sets a lower limit to the increase in concentrate consumption which would accompany the projected increase in milk production.

The situation in India probably contrasts with that in highly developed agricultures where projections of feed requirements are probably properly based on an assumption of no change or even an increase in feeding efficiency. However in highly developed agricultures the existing production situation is much more nearly homogeneous, particularly in regard to the extent to which production is for commercial markets with relatively similar actual and implicit prices.

Estimate II

Estimate II is based on a more complex set of assumptions than the other estimates. It includes the following assumptions :

(a) Increased milk production will be achieved through no changes in milk animal numbers; but rather through increased feeding of the existing animals.

(b) The increased consumption of milk in rural areas will be met by expanded production in the Distant Village sector.

(c) The increased consumption of milk in urban areas will be met by expanded production in the Urban and Nearby Village sectors with the proportion of this total met from the Urban sector declining by 5 percentage points each five years from 65 per cent in 1956 to 45 per cent in 1976. The occurrence of such a trend seems reasonable in light of the feeding efficiencies and relative costs in these sectors and the expected expansion in marketing facilities.

(d) The feeding efficiency for the expanded production of each sector will be given by the marginal productivity of added feed as shown by the production function on page 135. The values assumed are summarized in Table VI. It is implicitly assumed that heavier feeding rates will be prevented from causing further decline in the marginal productivity by the balancing effect of better breeding and management. Thus, it is assumed that each increment of one pound of concentrate will provide 0.50 pounds of milk in the Urban sector, 1.15 pounds in the Nearby Village sector and 1.42 pounds in the Distant Village sector.

TABLE VI—ASSUMED PRODUCTIVITY COEFFICIENTS IN MILK PRODUCTION (INDIA, 1956)

Sector	Average Productivity (pound milk/pound concentrate)	Level of Feeding pounds of concentrate per day)	Marginal value at this level of feeding (in milk per pound of concentrate)
Urban	1·5	5·60	0·50
Nearby Village	2·7	1·95	1·15
Distant Village	6·7	0·45	1·42

Source: See text.

The results of these assumptions are summarized in Table VIII. These assumptions call for nearly 50 million tons of concentrate feed in 1975-76 or over 2½ times as much as with Assumption I for the same years. This presumably provides an upper limit to concentrate feed consumption by dairy animals in 1975-76. In particular it is probably unlikely that expansion of production for rural consumption would be achieved in this way for this magnitude of increased production.

Estimate III

Estimate III also assumes that increased rural consumption will be met from expanded Distant Village production and that increased urban consumption will be met by increased production in Urban dairies and Nearby Village dairies in the proportions indicated under Estimate II. However, it is assumed that added milk for the urban market will be produced in effect by transferring Distant Village animals to Nearby Village and Urban dairies and thereby moving out the production function. Increased rural milk consumption will be met by increased distant village production at existing average concentrate-milk production ratios.

This set of assumptions is probably the most reasonable of the three. It suggests that by 1975 nearly three-quarters of the growth in urban demand will be met by expansion of Nearby Village production. This could be achieved by enlargement of the existing Nearby Village marketing areas through improved transportation and more chilling stations. Under such circumstances it seems reasonable that the farmers in the enlarged market area, facing better marketing opportunities and, in effect, a higher real price, would feed their animals better and move up the feed input-milk output production function. The urban dairies will expand production by bringing in Distant Village animals and moving out the function. Implicitly the expanded production for rural consumption will be met by increased cow numbers or increased feeding rates matched by increased feeding efficiency. Some improved breeding for production capacity is probably implicit in the assumptions for each sector.

With these assumptions, calculations of concentrate usage for each sector are as follows :

With expansion of Nearby Village areas to include previously Distant Village areas, production per animal of the newly included animals would increase by about 700 pounds per head and would require roughly an added 550 pounds of concentrate feed. Thus, added milk in the Nearby Village sector would require added feed in the ratio of 1.3 tons of milk to 1.0 ton of concentrate feed.

The increase in production in the urban sector is calculated in the same manner, except that implicitly the added cows from the Distant Village areas increase production by some 1,700 pounds per cow, using somewhat more than 1,700 additional pounds of feed. Thus, each added ton of milk would require approximately an additional ton of concentrate feed.

In the case of the added rural supply it was assumed that this would all be provided by expanded Distant Village production at a rate of 6.7 tons of milk to 1 ton of concentrate feed, which is the existing average ratio for this sector.[10]

The increase in milk production and in concentrate usage which follows from these calculations is shown for each sector in Table VII. Total concentrate requirements for milk stock increase from 5.1 million tons in 1955-56 to 24.3 million tons in 1975-76.

For the total increment to production in this period these assumptions provide an overall increment of 2.5 pounds of added milk for each pound of added concentrate. This compares with a base period overall average of 3.8 pounds of milk per pound of concentrate and a Nearby Village average in the base period of 2.7 pounds of milk per pound of concentrate.

TABLE VII—PROJECTION OF MILK PRODUCTION AND CONCENTRATE REQUIREMENTS, BY SECTOR, ASSUMPTION III, INDIA, 1956-1976

(Millions of long tons)

Sector	1955-56	1960-61	1965-66	1970-71	1975-76
			Production		
Urban	3·5	4·1	5·6	7·4	10·0
Nearby Village	1·9	2·7	4·5	7·3	12·1
Distant Village	13·4	16·1	22·7	32·4	46·0
Total	18·8	22·9	32·8	47·1	68·1
			Concentrate requirements		
Urban	2·3	2·9	4·4	6·2	8·8
Nearby Village	0·7	1·3	2·7	4·9	8·5
Distant Village	2·1	2·7	3·5	4·9	7·0
Total	5·1	6·9	10·6	16·0	24·3

The potential influence, on rural consumption, of a rise in the real price of milk is ignored in these calculations. An important feature of Estimate III is the assumption that urban markets will expand to include a portion of what are now Distant Village production situations. It is the real rise in price, offered by such improved market opportunity which provides the incentive for higher feeding rates. Such a real rise in price will have a positive effect on farmers' incomes, thereby presumably further increasing the demand for milk, while the relative price increase will cause substitution away from milk in consumption. Of the two effects the substitution effect will presumably be somewhat stronger. Hence the very factor which helps bring about increased rural production of milk will tend to cause somewhat lower rural consumption of milk. The demand projections on which these various estimates are based are not adjusted for this factor which serves to reduce derived demand for concentrates somewhat from these estimates.[11]

10. It is interesting to note what a high proportion of the total growth in both demand and supply is expected in the rural sector. Perhaps more than anything else this suggests to what a large extent growth in overall per capita income in a country heavily weighted towards the rural sector depends on increased rural incomes which in turn depend largely on increased productivity in agriculture.

11. The authors are indebted to Dr. J. P. Bhattacharjee for pointing out this interesting source of interrelationship.

Estimated Future Concentrate Supplies

Concentrate supplies are derived from various by-product sources as well as directly from foodgrain production. With expansion in domestic agricultural production and consumption, the supply of by-products will presumably increase. The extent to which additional foodgrains will be demanded for livestock feed will depend on the relationship between expanded demand for concentrates and expanded supply of by-products.

It is difficult to estimate the availability of by-product concentrate forms because of the usual problems of inadequate statistics and because of the previously described problem of clear definition of by-products and concentrates.

Estimates of the availability of by-product forms of concentrates have been made for 1960-61 to 1975-76, and are presented in Table VIII. These estimates follow closely the estimates of the NCAER in regard to bran, oil cakes and cotton-seed.[12] Added to the bran estimate is an estimate for chuni which is arbitrarily estimated to parallel the rate of growth of bran supplies, commencing from the base given in Table V.

The total availability of such by-products grows from an estimated 6.5 million tons in 1955-56 to 18.2 million tons in 1975-76.

It is arbitrarily assumed that concentrate feed requirements for workstock will go up in proportion to the gross land area sown to crops. For this purpose the NCAER projections of gross area sown were used.[13] The calculated requirement for workstock rises from 5.3 million tons in 1955-56 to 7.1 million tons in 1975-76.

Table VIII—Estimated Availability of By-product Concentrate Feeds, Concentrate Requirements, and Foodgrains Use for Concentrate Feeds, India, 1956-76

(Millions of long tons)

Item	1955-56	1960-61	1965-66	1970-71	1975-76
	By-product availability				
Type of feed					
Bran and Chuni	3·9	4·6	6·4	8·2	12·2
Oil cake and Cotton seed	2·6	3·8	4·6	6·0	6·0
Total ..	6·5	8·4	11·0	14·2	18·2
	Concentrate requirement				
Requirements for workstock	5·3	5·6	6·0	6·4	7·1
Requirements for milk production					
Assumption I	5·1	6·2	8·5	12·7	18·4
Assumption II	5·1	8·8	18·0	30·2	49.4
Assumption III	5·1	6·9	10·6	16·0	24·3
	Foodgrain requirements as concentrate				
Assumption I	3·9	3·4	3·9	4·9	8·1
Assumption II	3·9	6·0	13·0	22·4	39·1
Assumption III	3·9	4·1	5·6	8·2	14·0

12. NCAER, Dairy Products, *Op. cit.*
13. National Council of Applied Economic Research, Long-Term Projections of Demand for and Supply of Selected Agricultural Commodities, New Delhi, 1962.

Increased requirements of concentrate feeds for other types of livestock, such as poultry, are not explicitly included in these estimates. The error from this omission in the base period is very small compared to the likely error in the estimate of requirements for workstock and for the dairy sector itself. In the later period this error may be more substantial. However, many uncertainties surround this situation. For example, some of the growth in consumption of poultry and eggs may be in substitution for milk. This would cause this source of growth in concentrate requirement to be less in net than might first be assumed. In view of these and other uncertainties it was decided that it was better to ignore this sector than to include it with insufficient study.

Table VIII summarizes the assumptions concerning by-product availability, requirements for workstock and the requirements for milk production under various assumptions concerning feed-milk input-output ratios. The difference between concentrate requirements and by-product availability is reflected as foodgrains requirements for use as concentrate feeds.

With these assumptions a requirement of 3.9 million tons of foodgrains used directly as concentrates is depicted in 1955-56. With the most likely estimate (Estimate III) of concentrate requirements the deficit in concentrate to be made up from foodgrains grows to 14.0 million tons by 1975. The requirement is 8.1 million tons of foodgrains with Estimate I and 39.1 million tons with Estimate II. The fourteen million tons shown as required by Estimate III represent 10 per cent of the foodgrain production which NCAER considers most likely for 1975-76.[14]

There are a number of potential by-product feeds which have not been taken into consideration in these estimates. Molasses and citrus pulp are examples of by-products which are probably of little importance for use in livestock feed at the present time but which might become significant at some time in the future. The drain on foodgrains can be reduced to the extent such additional by-product sources are developed. The estimates of concentrate requirements indicate the pressure for development of such alternative by-product sources and the implications of not developing them.

With the most likely assumptions of Estimate III the percentage of concentrate requirements met from by-product sources drops insignificantly from 61 per cent in 1955-56 to 58 per cent in 1975-76. The much greater rate of increase in dairy requirements than in by-product availability, is balanced by the lesser rate of growth projected for workstock requirements.

Summary and Conclusions

The nature of available data provides a basis for widely divergent estimates of milk production and consumption in India. In this study an estimate of 19.3 million tons of milk produced in 1955-56 is taken as the base for other calculations. Of this total it is assumed that a little less than 20 per cent is produced in urban dairies, 10 per cent is produced in villages for sale in urban markets and the rest is produced for consumption in the producers' family, largely in villages distant from urban markets.

14. NCAER, Long-Term Projections, *Op. cit.*, p. 177.

Based on input-output relationships derived from study of farm data, it is estimated that slightly over 5 million tons of concentrate feeds were used for milk production in India in 1956. Somewhat over half of these concentrates were used in urban dairies to produce less than 20 per cent of the total milk supply.

Expected population growth and income growth, combined with high income elasticity of demand for milk in India will lead to a large increase in the demand for milk. Using an income elasticity of demand of 1.52, estimates of population and per capita income from the Third Five-Year Plan, and assuming no change in the relative price of milk provides an estimate of more than a 3½ fold increase in milk consumption between 1955-56 and 1975-76.

Because of the nature of the various milk production sectors in India and the conditions of expansion in demand it is likely that large expansion in milk production in India will be accompanied by a significant decline in feeding efficiency. That is, the percentage increase in concentrate requirements will be greater than the percentage increase in milk production.

Using the set of assumptions regarding concentrate use judged most likely, a 3½ fold increase in domestic production of milk by 1975-76 would require a nearly five-fold expansion of concentrate consumption by milk animals to over 24 million tons in 1975-76. Adjusting for increased concentrates fed to workstock and increased availability of by-product sources of concentrates, this would call for use of 14 million tons of foodgrains as concentrate feeds for livestock. This is equivalent to about ten per cent of the total production of foodgrains which the NCAER estimates for 1975-76.

With the assumptions judged most likely, the demand for concentrates in the Urban and Nearby Village sectors expands from 3.0 million tons in 1955-56 to 17.3 million tons in 1975-76. In contrast the demand for concentrates in the Distant Village areas expands only 5.0 million tons from 2.1 million tons in 1955-56 to 7.0 million tons in 1975-76. The Urban and Nearby Village sectors depend on the urban market for sale of milk. Hence if the immense marketing problems in moving large quantities of milk to urban markets are not satisfactorily met the demand projections for milk will fall short in the sectors in which the impact on concentrate requirements is greatest.

It is important to note that all the projections in this study assume constant price relationships. Presumably the price elasticity of demand for milk in India is numerically higher than −1.50. Hence any failure to expand production apace with demand will be masked by an increase in the price of milk which is relatively smaller than the shortfall in supply.

Finally it should be noted that with the assumptions of this study the growth in demand for concentrate feeds was relatively small during the period of the first two Five-Year Plans as compared with the expected growth in the decade of the Fourth and Fifth Plans. With the assumptions thought most likely the growth in concentrate demand for dairy animals is estimated as 3.4 million tons during the 1951-61 period. In the 1965-76 period the growth in demand for concentrate feeds for dairy animals is estimated at 19.2 million tons.