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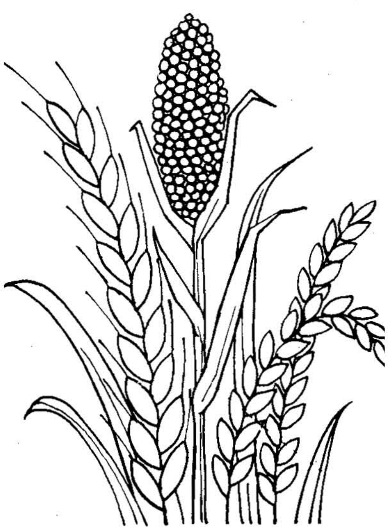

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SOME MICRO-ECONOMIC ASPECTS OF THE LIVESTOCK ECONOMY*

I

INTRODUCTION

Much of the debate on the economic role of livestock in rural India has been concerned solely with macro-level issues, and particularly with the question of whether or not, in conditions of assumed over-stocking, the social value of a marginal animal is negative.[1] This paper is concerned with a different issue the shape of the production functions of different categories of livestock producers, and, in particular, with differences between large and small farmers. The approach is purely deductive, and the results should be viewed as hypotheses to guide future research rather than demonstrated conclusions.

The data on which this paper is based were obtained from 18 socio-economic village survey reports published by the Agro-Economic Research Centre (A.E.R.C.) at the Sardar Patel University.[2] The data relate to various single agricultural years during the early 1960s; all villages are located in the States of Gujarat and Rajasthan, where the rural economy is more livestock-oriented than in most parts of India. Constraints of space prevent any extended discusssions of the strengths and weaknesses of the data base. Let it suffice to say that the data are very accurate by the standards of other Agro-Economic Research Centre surveys and that the villages were not randomly chosen, but represent a wide range of natural, social and economic environments.

Most of the hypotheses put forward derive from analysis of variables relating to stocks of milch animals and level of milk output. Some supporting analysis of manure production is described briefly. This paper comprises a summary of the results of a considerable amount of research; a very wide range of alternative hypotheses were examined, but no others found support in the data, and only positive results are reported here.

The mix of different kinds of animal stocks varied widely between the sample villages, primarily as a reflection of differences in the natural environment.[3] In order to usefully compare the productive potential of herds of different compositions, two standard yardsticks were evolved. They are Milch Animal Units (MAUs) and Physiological Animal Units (PAUs) respectively; the details of the coefficients used are to be found in Appendix 1.

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1. For a general view of the debate, see Azzi (2); Dandekar (6); Hanumantha Rao (9); Harris (10); Heston (11); Mishra (12); Odend'Hal (13); Raj (14); Royal Commission on Agriculture in India (15) and Sopher (17).

2. These studies will henceforth be referred to by their publication number, *e.g.*, A.E.R.C. Study No. 3; A.E.R.C. Study No. 21.

3. Camels and goats are more common in semi-arid areas, and buffaloes in the wettest areas,

II

THE OWNERSHIP OF MILCH ANIMALS

In our sample villages the ownership of milch animals was very closely correlated with household cultivation activity. Few households operating land did not own milch animals, and nearly all milch animals were owned by the cultivating households. In four (out of the 18) villages, no milch animals were owned by the non-cultivators; in only three villages did more than ten per cent of MAUs belong to the non-cultivating households; the proportion was very high (34 per cent) in only one village, which was significantly the only village to have fairly good and extensive common pastures, and the only one located in the semi-pastoral region of Kathiawar (western Gujarat).[4] In most cases the milch animals owned by the non-cultivators tended to be goats which, as grazing animals, are not dependent on crop residues.

Ownership of bovine milch animals is almost entirely confined to those with direct access to some bulk source of fodder. While this category comprises largely cultivators, it also includes the landless in (exceptional) areas of good common pasture, and, judging by information given in some of the village reports, a few non-operating landowners who feed animals from the residue of the crop share they collect as rent. Only a few of the very smallest cultivators did not maintain bovine milch animals.

These findings prompt the question why, outside the exceptional pasture-rich areas, the landless do not play a greater role in livestock production. The risk of loss if an animal dies might explain why the landless do not commonly own animals, but this would not prevent them from entering into arrangements to care for the animals owned by the wealthier neighbours on a product-sharing basis. Several factors probably interact to make such arrangements relatively rare: the fact that the landless do not have direct access to bulk fodder in the form of crop residues; the difficulty of 'policing' the distribution of milk such that the animal-owner is not cheated; the fact that milch animals respond very positively to the quality of the care they receive,[5] and may not receive the best of care from the non-owners; and the fact that the landless labourers have to be available for a full day's employment when required, and may find it difficult to fit the time-consuming demands of animal care into their schedule.[6]

III

MILCH ANIMAL STOCKING RATES

Of more fundamental importance than who owns milch animals is the question of how many belong to different categories of owners, *i.e.*, do stocking rates vary among different classes of farmers. The figures for stocking rates used in subsequent equations refer not to animal units per hectare, but

4. A.E.R.C. Study No. 11.
5. Cox (5).
6. Schluter (16), p. 89.

to animal units per 'standard land unit' (SLU), where an SLU is the average amount of land required in that village to produce one quintal of mixed cereals per year. The details of the concept and the calculations and assumptions involved are given in Appendix 2.[7]

There are two *a priori* reasons why one might expect the smaller farmers to stock more intensively per cropped hectare than the larger farmers. One is the indivisibility issue, which affects the smaller farmer most severely: if there are powerful incentives to maintain milch animals, then it is the smaller farmer who is most likely to maintain a notional part of an animal extra to his 'requirements' because the optimum number of animals for his holding is not a whole number. The second reason is that, as we know from other sources, large farmers tend to keep larger, better-fed, better breeds of animals than the smaller farmer who is less able to afford expensive breeds, less able to afford the relatively expensive fodder that they require, and more prone to diversify his risks by investing in numbers rather than in quality. Yet neither of these factors is of very great weight; they cannot explain the much higher stocking rates practised by the smaller farmers in our sample villages: within the same village, the smallest farmers commonly stocked six or seven times as many MAUs per SLU as did the biggest farmers.

The cross-village regression equation (Equation 1) suggests a statistically significant relationship between the overall MAU stocking rate at the village level and the prevalence of small farmers in the village population. The same equation also suggests that the presence of village wastes and pastures encourages farmers to hold more animals: the higher the ratio of these wastes and pastures to the cropped area, the higher the MAU stocking rate. (It is important to note, for the purposes of interpreting these results, that there is no statistical association between the availability of wastes and pastures and the prevalence of small farm households.)

Equation 1

Y_1 = 'MAU Stocking Rate', *i.e.*, the number of Milch Animal Units per Standard Land Unit; village averages.

X_1 = The 'Pasture Ratio', *i.e.*, the ratio of non-cropped to cropped land within the village boundaries.[8]

X_2 = The percentage of village households defined as 'small farmers', *i.e.*, those operating < 20 Standard Land Units.[9]

$$Y_1 = \underset{}{0.025} + \underset{(0.003)}{0.038X_1^{***}} + \underset{(0.0002)}{0.001X_2^{**}}$$

***Significant at 0.1 per cent; **Significant at 1 per cent.

$R^2 = 0.78$; $P < 0.001$; $n = 17$.

7. Readers are recommended to read this note both because it reveals clearly some of the assumptions on which most of the calculations in this paper are based, and because it seems to offer a workable solution to the problem of finding a valid measure for the comparison of farm size across widely differing physical environments.

8. The ratio could only be a crude proxy for the availability of feed from public pasture since it says nothing about the actual output of the pastures and since the administrative boundaries of the revenue village may not correspond to the spatial limits of villager's pasturing rights.

9. The choice of the particular definition of 'small farm' was fairly arbitrary. A farm of this size would not support an average-sized family.

Simple correlations (R): $X_1/Y_1 = 0.80$; $X_2/Y_1 = 0.70$; $X_2/X_1 = 0.46$.

How do we interpret Equation 1? The first regression coefficient is amenable to a single commonsense interpretation: the availability of public wastes and pastures encourages farmers to increase their animal stocks.[10] It seems, however, from the evidence given in section II above, that, except in areas of exceptionally good pasture, the feed available from public pastures and wastes is viewed as being strictly supplementary to bulk fodder from crop residues.

The second regression coefficient, combined with the information on intra-size class differences in stocking rates summarised in the paragraph above, suggest that the small farmers concentrate far more heavily than the large farmers on rearing milch animals. Why should this be so? The main reason is probably that livestock rearing is a fairly time-consuming activity,[11] and that the smaller farmers are more willing to invest the time required because the opportunity cost of their family labour is lower than for the larger farmer. This point has been amply demonstrated with reference to crop production,[12] and there is indeed evidence from other parts of India that the smaller farmers tend to devote more person-hours to the care of each animal than do the larger farmers.[13]

IV

ANIMAL FEED

In our sample villages there were four kinds of animal feed available: crop residues, cultivated fodders, purchased feeds (mainly oilcake), and the product of scavenging on public wastes and pastures. Sales of crop residues were never mentioned in the village reports, and they appear to be rare throughout India. Given that the smaller farmers generally stocked more intensively per cropped hectare than the large farmers, it seems certain that animals owned by the larger farmers received the most crop residues per head. Fodder crops were cultivated only in seven of the sample villages; in all cases the proportion of holdings devoted to fodder increased as the size of holding increased. This implies that animals owned by the large farmers also received more (nutritious) fodder per head. Quantitative evidence on the use of feed concentrates was given in only five villages reports; only in one case did expenditure per animal fail to increase with increases in the holding size.

It is only in respect of use of village wastes and pastures that we have no evidence on differential rates of utilization among different size classes of

10. Note that the "pasture ratio" does not appear as a proxy for some other variable: it was not significantly correlated with any of a wide range of socio-economic and environmental variables, including the incidence of small farmers, rainfall levels or stated soil quality.

11. A survey in Borsad taluka, Kaira district, Gujarat, a prime dairy area, revealed that an average of four person-hours per day were devoted to the care of a single buffalo (R.M. Patel, private communication). This figure is undoubtedly higher than the average for rural India.

12. *e.g.*, Bharadwaj (4), pp. 19-20.

13. *e.g.*, Government of India (8*b*), pp. 141-145; Schluter (16), p. 84; Bharadwaj (4), p. 107.

farmers. All other evidence suggests that animals owned by the larger farmers are the best fed, even after taking into consideration the fact that they are typically larger and superior breeds of animals, thus requiring more and better feed.

V

MILK OUTPUT PER ANIMAL UNIT[14]

Given that the larger farmers have bigger, better, and better-fed animals, the fact that they tended to obtain more milk per MAU comes as no surprise. Information was available to calculate average annual milk production per MAU for different size classes of farmers in 13 of the sample villages. In nine villages yields increased consistently or almost consistently[15] with increases in the holding size; in three villages there was no consistent pattern; and in only one village were the best-yielding animals those owned by the smaller farmers.

The analysis of the determinants of milk yields on a cross-village basis is somewhat more complex than intra-village comparisons because of the importance of major environmental differences between the sample villages. The main environmental difference was rainfall: annual averages varied by a factor of ten between semi-arid areas and the high rainfall central Gujarat plain. Areas of low rainfall have a greater comparative advantage in livestock rearing as opposed to crop production,[16] and there are breeds of animals in Western India which thrive under dry conditions. The drier the area, the more the rural economy is oriented towards livestock: at the inter-village level, there was a statistically significant negative relationship between average rainfall and the proportion of the cropped area devoted to fodder. This rela-

14. Data on milk production for the reference agricultural year were presented in a variety of forms and translated into a standard measure—kilograms. Where information on ghee production was not accompanied by a statement of the amount of milk used in its manufacture, the standard 'official' conversion ratio was used: one kilogram of ghee=18.8 kilograms of milk [Government of India (8a), p. 247]. The yield calculation was made with reference to the total stock of milch animals, dry and lactating. Lactation patterns are highly seasonal [Dharap (7), p. 81]; it would be misleading to calculate productivity with respect only to animals which happened to be in milk at the time the survey was conducted.

In one village report it is stated that, because of the custom of big farmers contracting out dry animals to be maintained by small farmers, the proportion of dry animals is low in the former groups and high in the latter. Examination of the table reveals however that the 'small farmers' are in fact, in local terms, 'middle farmers' operating 6-10 hectares; the small farmers do not in fact take in dry animals (A.E.R.C. Study No. 7, pp. 126-127). The proportion of dry animals among those owned by the 50 per cent (approximately) of smallest farmers is identical to the proportion among those owned by the 50 per cent of larger farmers. This latter pattern was also found in two of the three other villages for which data on dry animals were available (A.E.R.C. Study No. 10 and Resurvey No. 2). Only in one village (A.E.R.C. Study No. 9) is the proportion of dry animals markedly higher on smaller farms—yet in this case, paradoxically, milk yields per MAU were, untypically, highest for small farmers. It seems reasonable to conclude that the practice of contracting out (or simply selling) dry animals may have some distorting effect on calculations of milk yields by size class of holding, but is unlikely to have much effect at the aggregate village level and will not substantially affect the conclusions.

15. Whether or not the increase is 'consistent' or 'almost consistent' depends on the size classes chosen: the larger the size classes, the greater the likelihood of complete consistency. Various different size classes were used in the village survey reports.

16. In addition, since the variability of rainfall is inversely related to average rainfall levels [Spate and Learmonth (18), p. 47], livestock rearing comprises a major stabilising element in the rural economy of low rainfall areas (A.E.R.C. Study No. 22, Chapter 2, pp. 60-61).

tionship was closest when rainfall was expressed as a reciprocal $\left(\frac{1}{\text{rainfall}}\right)$[17]; quite why this functional form should be the best fit is not quite clear, but we have any way used the reciprocal of average annual rainfall as a proxy variable for the effect of the natural environment on milk yields in the analysis reported below.

The effect of this natural environment variable on inter-village differences in average milk yields per MAU is illustrated in Equation 2: a high proportion of the variance is explained by this variable (the first dependent variable) alone. However, a significant proportion of the variance in yields left unexplained by the environmental variable is 'explained' by the second dependent variable—the pasture ratio. The higher the pasture ratio, the lower are average milk yields per MAU.

Equation 2

$Y_2 =$ Average annual milk yields (kilograms) per MAU; village averages.

$X_3 =$ The reciprocal of average annual rainfall at the recording station nearest the village.

$X_1 =$ The 'Pasture Ratio' (see Equation 1).

$$Y_2 = \underset{}{419.593} + \underset{(7913.616)}{30933.925X_3^{***}} - \underset{(152.962)}{363.810X_1^{*}}$$

***Significant at 0.1 per cent; *Significant at 2.5 per cent.
$R^2 = 0.68$; $p<0.001$; $n=15$.

The result is perfectly consistent with the earlier finding that the availability of public wastes and pastures encourages higher stocking rates. The feed obtained from this source is poor in quality and also scarce because of competition from other animals; it is quite consistent that a high level of dependence on public grazing should be associated with low milk output per animal unit.

VI

THE EFFICIENCY OF MILK PRODUCTION

Our analysis of the efficiency of milk production can at best be only partial, since we are dealing with only one of the outputs of a multi-product activity, and we do not have anything like enough information on all the relevant private and social costs and benefits. The results of our partial analysis are however sufficiently striking to merit consideration.

17. *Equation 4:*
Y_4=Proportion of gross cropped area under fodder crops; villagewise.
X_3=The reciprocal of average annual rainfall (see Equation 2).
$$Y_4 = 0.895 + \underset{(161.979)}{706.203X_3}$$
$R^2=0.57$; $p<0.001$; $n=16$.

Taking into account the general context in which arable land is scarce and human labour relatively abundant, we have first treated arable land as a scarce resource, and examined inter-class differences in annual milk output per Standard Land Unit. On an intra-village basis these data were available by size class of farmers for 13 of the sample villages. They present what is at first sight a most surprising result: in ten cases milk yields per cropped hectare *decreased* as the holding size increased, and in the remaining three cases there was no clear trend. This result indicates, perhaps somewhat surprisingly, that it is the smaller farmers who are, on this measure, the most efficient users of arable land. Regression analysis of differences in average values by village confirms this finding. It was hypothesized that, while average milk output per Standard Land Unit (villagewise) would in large part depend on the environmental variables explaining much of the variance in milk yields per animal unit (*i.e.*, the 'Pasture Ratio' and rainfall—see Equation 2), a significant increase in variance explained would result from adding a third independent variable—the proportion of 'small farmers' in the village population.

Equation 3

Y_3 = Average annual milk production (kilograms) per Standard Land Unit (cropped land only); village averages.
X_3 = The reciprocal of average annual rainfall (see Equation 2).
X_2 = The proportion of 'small farm' households in the village population (see Equation 1).

$$Y_3 = 5.234 + \underset{(383.667)}{1359.592\, X_3^{***}} + \underset{(0.238)}{0.509\, X_2^{*}}$$

***Significant at 0.1 per cent; *Significant at 5 per cent.
$R^2 = 0.56$; $p<0.001$; $n = 15$.

The results confirm our expectations, except that one of the environmental variables—the 'Pasture Ratio'—had no statistically significant explanatory power. (It is omitted from Equation 3.) If our basic hypotheses are correct, there are two possible explanations for this. The first is simply that the data on pasture ratios are both crude and proxies for some other variable, and that the odd 'bad' result is therefore likely. The second will become more clear after reading the succeeding section; it is basicaly that it is the smaller farmers who predominate among users of village pastures and wastes, and that the detrimental effects of the use of public pastures on yields per animal units (section V) are more than outweighed by the factors, discussed below, which make the small farmers the most efficient producers per unit of scarce arable land.

The most important point emerging from these figures is that, despite their lower average milk yields per MAU, the smaller farmers actually produce more milk per Standard Land Unit. This is clear because the smaller farmers stock more MAUs per acre (section III); they achieve a greater aggregate output by stocking more lower yielding animals than fewer higher yielding ones. But this argument brings us face to face with the widespread view that the Indian livestock economy is in a general situation of negative marginal output per animal. If this is the general situation, then one would expect that the higher stocking rates practised by the small farmers would offer them no prospect of achieving higher yield per unit of land than the large farmers; every additional animal would *reduce* aggregate milk yields.

The paradox is however less rooted than it might first appear. It is possible both for the interpretation of our quantitative results above to hold and for the thesis of negative marginal productivity to be generally true. There are four factors which could help bring this about; they probably operate jointly. The first is that the small farmers probably depend much more heavily than the larger farmers on the use of public pastures and wastes. This could to a large extent compensate for the fact that the animals belonging to the big farmers are better fed from other sources (section IV). The second point is that, in so far as the animals belonging to both the classes of farmers are fed from the same source, the additional labour time spent per animal by the smaller farmers (section III) may often serve to increase yields. For example:—the more finely fodder straw is chopped, the more palatable it becomes to the animal, the less is the energy required for digesting it, and the greater the energy available for productive uses;[18] if animals are stall-fed from cut grass, the smaller farmer may be more willing to spend time in this activity; if animals are allowed to graze freely, closer supervision may reduce the energy they use in seeking food. The third point is that many activities related to livestock are best undertaken at particular hours of the day: there are optimum times for feeding and watering. The relatively under-employed small farm family may be better able to observe time tables than busier larger farmers or their hired servants.[19] The fourth point is that milk yields are popularly known to depend partly on the quality of the psychic relationship between animal and herdsman: recent research has confirmed this.[20] Hired labourers have less incentive than owners to behave appropriately, and often achieve lower milk yields.[21] Thus, in so far as larger farmers depend on hired labour to care for their milch animals, yields may suffer.

If we only consider the inputs of relatively abundant labour in small farm households and relatively scarce arable land, then it appears that the smaller farmers produce milk by using relatively more of the abundant resource and relatively less of the scarce resource than the larger farmers. The question of which is actually the most efficient at producing milk could only be answered if we could put a value on the use of public pasture. It is practically certain that in most cases there is a negative marginal output of public pasture consequent on adding an additional animal: pastures are already mostly over-

18. Whyte (19), p. 96.
19. Schluter (16), p. 89.
20. Cox (5).
21. This was the reason given for low milk yields of some very large farmers in one of our sample villages (A.E.R.C. Study No. 9); this was the only village where smaller farmers achieved the highest milk yield per MAU.

grazed, denuded and eroded. If the small farmers are indeed heavily dependent on public pastures, then under existing institutional conditions, this constitutes a strong argument against any claim they might have to be the most efficient milk producers.

VII

MANURE PRODUCTION

An analysis was conducted of manure production for nine of the sample villages for which data were available. The results closely parallel those of the analysis of milk production, and it is therefore necessary only to summarise them briefly.

With respect to patterns of ownership and stocking rates of Physiological Animal Unit (PAUs—see Appendix 1), the results are virtually the same as in the analysis of milk production. This is scarcely surprising as the stock of MAUs comprises a large fraction of the stock of PAUs. Equally similarly, manure yields per PAU increased with the size of holding. In the analysis of manure output per Standard Land Unit, the intra-village analysis indicated that output tended generally to decrease as the holding size increased, while the cross-village regression analysis yielded a statistically insignificant result. These findings initially introduce the same kind of paradox which occurred in the case of milk production: in a situation of assumed negative marginal output to the additional animal, the densely stocked small farmers would not only be expected to produce less manure per animal unit, but even less per Standard Land Unit, in comparison with the big farmers. The factors which may explain this apparent paradox in the case of milk probably also apply here, although in the case of manure output special stress should be put on public pastures as a source of feed; manure output is not significantly affected by the ability of the smaller farmer to give the animals more care and attention.

VIII

IMPLICATIONS

The implications of this paper can be summarised very briefly. In the area to which the data relate, the small farmers tend to specialise more in livestock production than do other categories of the rural population;[22] they stock relatively densely and obtain less output per animal. By combining relatively abundant family labour with the over-exploitation of public pastures, they manage to obtain at least as much output, and perhaps often more, per unit of arable land than do the larger farmers. Were some means found to regenerate, conserve and restrict access to public pastures, it is likely that the small farmers using family labour would prove more efficient producers of animal products than the larger farmers, especially if resources were valued at their social opportunity cost.

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22. See also Bardhan (3), p. 307, for supporting evidence.

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APPENDIX 1

Milk Animal Units and Physiological Units

In order to evaluate the productivity of the milch goat against the cow, and the two against the she-buffalo, all milch animals were expressed as Milch Animal Units (henceforth MAUs), which are approximate measures of relative milk-yielding capacity of the different species. The she-buffalo was taken as the standard (1 MAU). The cow was evaluated at 0.8 MAU on the basis of generally accepted estimates of relative milk-yielding capacity. The only other animal maintained in the samlpe villages and yielding milk for human consumption was the goat; relatively little of its milk is actually used for human consumption, and the results of the analysis would have been almost unchanged had the milch goat been excluded from consideration. It is however included (where necessary) for the sake of consistency, and each milch goat is evaluated at 0.06 MAU on the basis of relative milk productivities in the only village (A.E.R.C. Study No. 18) for which the necessary information is given. Rough calculations indicate that the precise choice of conversion ratio had little impact on the results.

It is important to note that the MAU coefficients reflect milk-yielding capacities; they serve a different purpose from the Physiological Animal Units (PAUs) reflecting body size, which are used in the analysis of manure productivity. However, the ratio of cows to she-buffaloes is almost identical in both sets of coefficients (0.8 in the case of MAUs and 0.77 in the case of PAUs), and it is therefore quite justifiable as well as easier for both the author and reader to use the MAU measure throughout the section on milk production to reflect relative body-sized (and their feed requirements) as well as milk-yielding capacities.

In the case of PAUs, the author simply adopted the conversion coefficients, adapted from FAO figures, which are used by the Agro-Economic Research Centre, Sardar Patel University (A.E.R.C. Study No. 16, p. 90): Cow = 1.00; Bullock = 1.00; Buffalo (male or female) = 1.30; Bovine young = 0.75; Adult ovines = 0.15; Young ovines = 0.1125; Camel = 0.96; Horse = 1.00; Donkey = 0.75.

APPENDIX 2

Standard Land Units

In a sample of villages ranging from the fertile high rainfall Gujarat plain to infertile desert villages, a unit of land cannot be assumed to be of equal productive potential even in a very approximate sense. There is a need for an indicator of land quality which will permit meaningful inter-village comparisons. The use of the monetary value of crop yields was rejected partly because price formation in rural India is very much affected by local factors, but principally because this would give undue weight to the areas devoted to high value cash crops (tobacco, vegetables).

The solution chosen was to use the average weighted yield per hectare (in quintals) of cereal crops as the index of soil quality. (In some cases, cereals were grown in mixtures with other crops. This presented no calculation problem because the yield estimates given in the village reports refer only to crops grown in pure stands.) This technique is possible and appropriate where cereals are the staple food-stuff and occupy a large proportion of the cropped area of most villages, and almost 100 per cent of some. The essential similarity of the harvested grains of all cereals makes it appropriate to use weight for the comparison. There are a number of fairly obvious imperfections with this index of productivity, but there appears to be no better alternative. As expected, the weighted average cereal yields correlated fairly closely with average annual rainfall ($R^2=0.44$; $p < 0.001$), while deviations from the regression line plotted on the scatter diagram could usually be easily explained by information given on soil fertility or the availability of irrigation facilities. The output data refer only to one year; it is certain that rainfall variability accounts for part of the unexplained variance.

Land quality is then measured by the average weighted cereal yield per hectare; these data are used to calculate Standard Land Units (SLUs), where one SLU is the amount of land required to produce one quintal of mixed cereals per annum at a cropping intensity equal to the village average.

This index has a number of obvious imperfections. Its usefulness for the present purpose, *i.e.*, making comparisons between primarily cereal-growing villages located in a wide range of different physical environments, seems attested by the results obtained.

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IMPACT OF LIFT IRRIGATION ON CROPPING PATTERN AND CROP YIELDS: BASED ON A FIVE-VILLAGE SURVEY IN BHIWANI (HARYANA)

Bhiwani is one of the eleven districts of Haryana, which is adjacent to the desert areas of Rajasthan and reflects to a considerable degree the topographical features of the adjoining State. A large part of the soil is sandy or sandy loam, the texture soft and light and the quality extremely permeable and deficient in crop nutrients. The sub-soil water is either brackish and unfit for cultivation purposes, as in Tosham, or is available at a great depth, as in the case of Loharu, Jui and Chang, or both, as in the case of Siwani.[1] It is, thus, primarily dependent on rains, which itself is scanty and erratic and confined to only a few months in a year.[2] The seasonality and the in-

1. District Census Report, 1971.
2. The average mean rainfall in the district is 370 millimetres (mm.) as against 401.8 mm. in Hissar and 1,201.3 mm. in Ambala district out of which about three-fourths is received during the three monsoonal months, *i.e.*, 16th June to 15th September and the balance in the winter months. Compared to the national average, "the rainfall is very scanty and erratic confined to only a few months in the year." See Project Report for Integrated Development of Canal Command Areas, Deputy Commissioner, Bhiwani, September 1973. The total number of rainy days, as per average of Hissar area, is 25.7 and the Xerothermic Index for the year is more than 300. (The Xerothermic Index is the number of days which can be deemed to be dry from the biological point of view.)