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LABOUR USE IN INDIAN AGRICULTURE:
An Analysis Based on Farm Management Survey Data

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Introduction

1. The existence of wide variations in the intensity of human labour use in agriculture as between crops, regions and classes of farmers has been widely noted especially in the context of the debates on the relation between farm size and productivity per unit area 1/ and on the factors determining rural wage rates. 2/ There are also several studies dealing with the impact of irrigation, introduction of HYVs, tractorisation, and other important changes in agricultural technology, 3/ on the level and pattern of employment in agriculture. But the relation between overall human labour use and agricultural production and the factors determining them have received remarkably scant attention. The significant exception is Ishikawa's book "Economic Development in the Asian Perspective." 4/

2. This book, which was in the nature of a comparative study of development in Asian countries, focussed on the large differences in the intensity of human labour input in agriculture as between various Asian countries: ranging from 50 mandays per hectare of cropped area in parts of India to around 500 in Japan. Ishikawa found a strong positive correlation between physical output per unit area and human

labour input per unit area. While the labour use was positively associated with the level of other current and capital inputs (especially irrigation and fertilisers), the use of the latter cannot increase output per unit area indefinitely. And beyond a certain limit, major improvements in irrigation and in the organisation of farms to permit more efficient water use were necessary in order to bring about an upward shift in production possibilities and permit a further rise in the intensity of labour and other current inputs.

3. Ishikawa's hypothesis seems to be far more convincing in relation to the course of agricultural development in Japan (as well as Korea and Taiwan) than as an explanation for the variations in intensity of human labour inputs between different Asian countries. On closer examination[5/] it is found that, apart from problems of comparability in concepts and measurement, the relation between crop output per hectare and labour input per hectare is considerably weakened when countries like Malayasia and Sri Lanka and Philippines, with a relatively high proportion of area under tree crops, are included in the sample. Secondly, the role of irrigation in the intensification of cropping is considerably more complex than Ishikawa suggests. Climatalogical factors (temperature, quantum of rainfall and its seasonal distribution) have a major role in determining the need for supplementary irrigation, the type of irrigation works which are possible, as well as the ease with which the problems of efficient water use can be overcome. In all these respects, a comparison of different Asian countries, and in particular of countries of South and East Asia, based mainly on the percentage of area under irrigation, or the sources of irrigation, is far too simplified to

provide the basis for a proper understanding of the problem and, even more, as a guide for policy. Thirdly, it seems likely that one reason for the exceptionally high levels of human labour input in East Asia may have something to do with the fact that this region, unlike South Asia, uses hardly any animal power.

4. A more defenitive analysis of the reasons for the inter-country differences in labour intensity of agriculture is necessary: The differences between South and East Asia in particular are too large to be explained away merely by differences in concepts and measurement. And if it were possible for South Asia to achieve anything approaching the levels of labour intensity obtaining in East Asia, the employment outlook for the countries like India would be profoundly different from what is generally believed at present. But we are not in a position to undertake such an analysis partly for the reason that the detailed data necessary for the purpose are not easily accessible to Indian researchers. Pending that, it seemed to us worthwhile exploring the differences in labour intensity of agriculture within India on the basis of detailed data from the Farm Management Surveys (FMS) conducted during the Fifties and the Sixties. This paper presents the first results of our efforts.

5. The paper is divided into four sections. Section I outlines an analytical framework in which the factors determining the labour intensity of agriculture can be explored. Section II presents the results of empirical analysis, based on cross-section data, of differences in labour intensity of crop production as a whole across, and within, selected districts. Section III focusses on the inter- and intra-district

variations in human labour use for one of the major crops of India, namely, paddy. Section IV summarises the available information on changes in labour use (between the mid-fifties and mid-sixties early seventies) for three districts which have experienced relatively rapid rates of agricultural growth.

I

An Analytical Framework

6. Being one of the inputs entering the production process, the level of labour use in agriculture depends on the relation between (a) output, (b) a combination of inputs (which are defined by the nature of technology), and (c) the relative prices and productivities of different inputs as well as the degree of substituability between them (which determines the particular input combination consistent with maximum returns to resources used in the production process). The conventional formulations of the production-function, in which output is expressed as a function of labour and capital, are particularly ill-suited to analysing labour use in agriculture. Part of the problem is the difficulty of getting meaningful measures of the capital stock at the farm level in a context where a great deal of land and water improvement is undertaken by the public sector for the benefit of large groups of farmers. The more important difficulty arises from the fact that some types of capital investments (e.g., reclamation and water development) increase labour requirements, some (like mechanical harvestors and threshers) are clearly labour

displacing, and others (notably animal power) seem to be complementary to human labour.

7. Faced with these difficulties, agricultural economists have modified the conventional formulations of the production function by replacing "capital" with irrigation, fertilisers, human, bullock labour and machine power all of which are elements of fixed and working capital used in agriculture.[6] The results, however, have not been wholly satisfactory. There is invariably a high degree of multicollinearity between some input variables (usually between irrigation and fertilisers, and between human and bullock labour). The existence of a high correlation between two input variables is taken to be indicative of complementarity: While this may be valid in a statistical sense, evidence from agronomic and fertiliser experiments suggest that such a conclusion can be highly misleading: For instance, though the extent and quality of irrigation is an important determinant of the limits to fertiliser absorption as well as the yield response to fertiliser, the level of fertiliser use at any given level of irrigation can, and does, vary within wide limits and this in turn should be expected to have a significant influence on yield.

8. The fact that this is not reflected in the regressions may be due either to the inherent limitations of the usual production functions in capturing the true of nature of the underlying technical relations or, perhaps more likely, to the low range of variability of fertiliser use at any given level of irrigation within the sample data. There is also the problem of defining the irrigation variable in a meaningful way. The percentage of

area irrigated, without reference to its quality or to the moisture supply from rainfall is much too crude a measure. Obvious as this may seem, most production function analyses use only the percentage of irrigated area as an explanatory variable; a few distinguish between canals and tubewells; but hardly any allow for the quantum and seasonal distribution of moisture from rainfall. That the proper specification and measurement of these different components of moisture availability, and their inter-actions with fertilisers, presents many difficulties is no argument for resorting to expedient simplifications. This is an area where both analytical and empirical research is still in its infancy[7/] and where further intensive work could be highly rewarding.

9. The existence of multi collinearity between explanatory input variables presents serious problems of interpreting the estimated production functions. Faced with the fact of multi-collinearity, it is common practice to drop out some of the input variables which are significantly correlated with each other and re-estimate the parameters of the function: Which input variables are to be dropped, and which to be retained is, however, often determined by a judgement regarding what is considered relevant for the purpose at hand or on the basis of some apriori hypothesis (not always made explicit) about which input variables are more important as a causal factor.

10. Moreover, the interpretation of coefficients, in the presence of multi-collinearity is problematic. For instance, one frequently comes across functions in which human labour is included as an input,

but bullock labour and implements are excluded on the grounds that these are complementary to human labour -- a complementarity which is supposed to be established by the high positive correlation between human and animal labour. The coefficient for human labour in such a function cannot be considered as measuring the marginal product of human labour alone; rather it represents the marginal product of a combination of human labour, animal power and associated equipments. The interpretation of the coefficient raises even more difficulties when the ratio of human to animal labour varies, as it always does, within the sample. Though these problems are recognised, one still finds attempts to use the coefficients for human labour derived from functions of the above type as approximating its marginal product and comparing it with actual wage rate to test the efficiency of resource allocation[8] or the efficiency of rural labour market.[9]

11. Ignoring the complex inter-actions as between different inputs has also been responsible for wrong inferences about the impact of mechanisation on human labour use. Several studies[10] have reported that the tractorised farms tend to have high cropping intensities, higher levels of fertiliser use, and higher levels of human labour inputs than bullock operated farms, and that the differences are statistically significant. From this, they infer that tractorisation may in fact promote more intensive use of human labour. But this inference is quite invalid for the simple reason that the input-output relations used for the regression analysis have been so defined as to confound the effects of tractorisation

with those of other factors (notably irrigation) on the levels of productivity and labour use. Since differences in cropping intensity, fertilisation and yield are also found to be significantly associated with the degree of irrigation development and its quality, valid inferences about the effects of tractorisation on human labour input cannot be made unless tractorisation is shown to be a pre-condition to expanding and/or improving irrigation, or that tractorisation by itself has a positive effect on crop pattern or cropping intensities.

12. Given the pitfalls in the conventional approach to estimating production functions for agriculture, it seems desirable to explore alternative ways of tackling the problem. For this purpose, one might make a broad distinction between the physical-biological determinants of crop yields (soil conditions, moisture availability, the genetic potential of seeds, fertilisers and manures, pesticides and weedicides) and the energy inputs (in the form of human, animal or mechanical power) to perform various operations to utilise the physical-biological input factors.

13. There is ample scientific basis for postulating that crop yields depend basically on the quality of the soil, the quantum, timing, and assurance of soil moisture, and the volume of nutrients effectively available to the crop. The last mentioned factor is a function not only of the volume of nutrients applied (whether as farm yard wastes, green manures, or as artificial fertilisers) but also on how effectively the incidence of weeds, pests and diseases are controlled. If, as is typically the case, actual levels

of input use, their efficiency and, consequently, yields are below what is demonstrated to be feasible under controlled conditions, the divergence can be taken as a reflection of the atypical nature of the controlled experiments, and/or a certain loss of "efficiency" in transfering the techniques from experimental conditions to conditions of mass use.[11/] Both these contingencies, however, arise from factors (such as the lack of adaptive research to evolve varieties/techniques suitable to specific local conditions, lacunae in the extension services, and lags inherent in learning of new techniques by farmers in-the-mass) of an institutional character rather from a shortage of energy inputs.

14. The role of the latter is essentially to perform various operations associated with the use of the physical inputs. More intensive irrigation, fertilisation and application of plant protection chemicals clearly require higher inputs of energy in the respective operations. In so far as the degree of intensity and care required in preparatory and sowing operations is itself a function of the quality of land (its physical characteristics, depth, and moisture supply) which determines potential yields, the amount of energy put into the former is also a function of the latter. And, if the work involved in harvest and post-harvest operations is a function of the quantum of yields, it is also likely to be an increasing function of the use of irrigation and fertiliser use.

15. If this view is correct, we could make the following postulates: (1) Yields are fundamentally a function of the level of irrigation, manures and fertilisers and plant protection chemicals; and (b) The

quantum of energy input can contribute to yields only through the latter and should not be treated as an independent causal factor. This implies that the energy inputs will also be a function of the level of physical inputs and to the extent the energy requirements for applying different inputs and for operations associated with them differ, also on their composition. However, if information on the physical input variables in the required form and detail is not available (and this is in fact the case), it is convenient to examine how the various energy inputs are related to the overall yields, which reflect the composite effect of the physical inputs.

16. The assumption that the crop yields are fundamentally determined by the quantum and efficiency of physical inputs and that energy inputs by themselves do not contribute, at any rate significantly, to yields could be challenged. It is often argued for instance, that tractors raise yields by permitting deeper ploughing and, more importantly, help increase cropping intensity, and possibly facilitate sowing of high value crops, by greatly speeding up the pace of harvesting and preparatory operations. Thus, if the time available between harvesting and threshing of a kharif crop and sowing the rabi crop is very short and farmers were to rely wholly on human and animal labour, it may be physically impossible to complete all the necessary operations in time. To the extent this is true, clearly larger energy inputs, at least in the critical period, <u>by itself</u> will make a difference to the productivity of land. However, the available empirical studies do not conclusively corroborate either of the above claims[12/] regarding the benefits of tractorisation. In any event, since the use of mechanical power is as yet relatively

small in most parts of the country, ignoring its direct effects on productivity is unlikely to seriously vitiate analysis of data for past years.

17. The other argument could be that weeding and interculture, which prima facie could have a significant effect on crop yields, need not necessarily be done only with the help of chemicals; they can be (and, in the case of inter-culture, have to be) done by human/animal power. In so far as energy inputs are a substitute for chemicals, or are the only way to perform these operations, their intensity could directly affect yields. This is a point which will try and verify later in the paper. Even if it were true, since the energy input into these operations is a relatively small fraction of the total, there is no warrant to abandon the broad framework of analysis outlined above.

18. This framework has the added advantage that it offers greater scope to examine the degree of complementarity or substitutability between the three different sources of energy namely, human labour, animal labour and mechanical power, as well as the factors responsible for variations in the mix of these energy sources. This problem, incidentally, has received far too little attention in the past: The available literature generally assumes bullock labour to be strictly complementary to human labour, and concentrates mostly on the extent to which machines tend to displace human labour. The positive association between human and bullock labour in the aggregate however, conceals considerable variation in the ratio of the two sources of energy both overall, and, even more, in particular operations. A better understanding of the technical and the economic reasons for the variations in the human-animal energy mix

will be possible if we examine the behaviour of the mix by major agricultural operations. The quantum of human labour input per unit area in agricultural operations (individually and collectively) will then be viewed as a function of total crop yield per hectare (which is assumed to define the overall energy requirement), the quantum of animal or machine power used, and the relative prices of the three sources of energy. Of course the relative prices should be adjusted for differences in relative efficiencies in the use of energy from different sources.

II

Analysis of Cross Section Data for All Crops

19. The basic data on the average crop output, irrigation, human and labour inputs per hectare of gross cropped area and some other relevant variables for selected districts are set out in Table 1. The districts are arranged in ascending order of crop output per hectare evaluated at all-India average prices for various crops prevailing in 1970-71 to 1972-73.[13/] We shall present the results in two stages: (1) The extent to which differences in physical factors can explain observed variations in per hectare output; and (2) analysis of the factors underlying differences in the intensity of human labour input per hectare. In both stages, the results of analysis based on inter-district cross section will be discussed first, followed by those based on intra-district cross sections for individual districts and groups of districts.

Table 1: Basic Data relating to Total Crop Production and Associated Variables in Selected Districts

District	Survey period	Output	Percent Irrigated Area	Proportion of Irrigated area under wells	Proportion of area under paddy & sugarcane	HLD	BLD	HP	Cost of HLD / Cost of BLD	Hired Labour / HLD	CI	Total	Percentage of rainfall in June-September
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1. Ahmednagar	1954-56	265	18.5	.286	1.0	44.3	19.2	.014	.81	.32	104.8	574	77
2. Nasik	1954-56	299	12.8	.260	0.2	56.1	25.4	.017	.77	.29	101.8	1059	77
3. Pali	1962-64	303	24.0	.542	0.1	65.7	22.3	.016	.39	n.a	102.4	369	96
4. Surat-Bulsar	1966-68	817	18.3	.230	23.5	168.5	11.2	.041	.10	.60	118.0	2906	99
5. Amritsar/ Ferozepur	1954-56	838	74.0	.540	1.1	51.0	22.1	.080	.51	.27	129.0	693	86
6. Sambalpur	1957-59	894	10.4	.240	35.5	106.7	30.0	.004	.60	.42	97.0	1300	92
7. Cudappah	1967-69	1075	35.4	.430	16.8	75.3	19.5	.088	.49	.68	93.0	697	49
8. 24 Parganas	1954-56	1137	2.0	.001	81.0	112.0	17.8	.006	.78	.33	105.0	1490	75
9. Meerut/Muzaffarnagar	1954-56	1153	72.9	.247	23.5	93.2	29.6	.031	.23	.32	134.4	1105	80
10. Cuttack	1967-69	1210	50.6	.115	73.7	101.2	14.2	.003	1.07	.40	140.0	1401	82
11. Hooghly	1954-56	1299	25.3	.474	64.0	146.6	20.0	.021	1.02	.42	106.0	1420	75
12. W. Godavari (Paddy zone)	1957-59	1371	75.5	.028	70.5	103.0	15.7	.003	.24	.79	156.0	1195	63
13. Deoria	1965-68	1551	30.1	.978	29.8	100.9	24.9	.064	.28	.41	128.5	1022	77
14. Ferozepur	1967-69	1622	87.0	.517	4.9	60.0	13.5	.125	.46	.49	129.0	327	90
15. Coimbatore	1970-72	1743	50.0	.420	16.0	93.4	9.1	.299	.33	.85	143.0	773	28
16. Thanjavur	1967-69	1818	91.0	.013	82.6	118.8	24.1	.030	.97	.75	151.0	1229	30
17. W. Godavari (Tobacco zone)	1957-59	1871	19.9	.377	25.7	145.0	16.1	.003	.33	.78	119.0	1092	66
18. Muzaffarnagar	1966-68	2006	92.0	.386	32.3	73.2	19.1	.142	.21	.40	139.0	860	87

Note: 1. Unless otherwise indicated, all figures are three year averages per hectare of gross cropped area.
2. Output is evaluated uniformly at All-India average prices [redacted]

Variations in Crop Output Per Hectare

20. Crop production per hectare of gross cropped area (valued at the all-India average prices prevailing in 1970-72) ranges from an average Rs.265 in Ahmednagar (1954-57) to over Rs.2000 in Muzaffarnagar (1966-69). The frequency distribution of the sample districts by levels of productivity (See Table 2) shows a fairly wide dispersion of the values. The range of variation will naturally increase as we move from district averages to averages for different size-classes of farms and on to individual sample farms. It has not been possible for us to re-estimate the output per hectare on a uniform price-base for size-classes or for individual farms. However, we have analysed the variation in output per hectare by size-classes by grouping districts, and in some cases by zones or sub-regions within a district, which were surveyed in the same period.

Table 2

Distribution of Sample Districts by Level of Product per hectare

Productivity Range (Rs.)	250-500	500-750	750-1000	1000-1250	1250-1500	1500-1750	1750-2000	2000
Number of districts	3	nil	3	4	2	3	2	1

Simple average output per hectare for sample district : 1182

Coefficient of variation : 0.46

21. In the case of the inter-district cross-section we have data on total rainfall and its seasonal distribution, the extent of irrigation, as well as the extent of mechanisation for all the selected districts. Information regarding manures and fertilisers, which determines the quantum of plant nutrients applied to crops, is available only for 11 out of the 18 districts. We have not considered other inputs like the quantum and quality of seed, or the use of plant protection chemicals.

22. In terms of the hypothesis outlined in Section I, we should expect that inter-district variations in crop production per hectare to be largely explained by differences in moisture availability and intensity of fertilisation. It can be seen from Table 3 that there is indeed a positive and statistically significant association between crop yields on the one hand, and irrigation and fertilisation on the other. However, moisture requirements for plant growth are met not only by irrigation but also from natural rainfall. Moisture supply from rainfall relevant for plant growth depends on its quantum as well as its seasonal distribution: A high rainfall concentrated in a few months of the year has very different consequences for crop pattern and yields than a moderate, but evenly distributed, rainfall. For this reason, the total annual rainfall and the proportion of total rainfall falling in June to September, were introduced as additional explanatory variables.[14] The former is found to be not significantly correlated to crop yields; while the seasonal distribution of rainfall and yields shows a negative, though statistically insignificant, association.

Table 3

Total Correlation Coefficients Between Crop Output per hectare and Selected Physical Factors

Correlated variables	Total Correlation coefficients 1/
Crop output/ha. and percent of Irrigated area:	+0.545**
Crop output/ha. and nutrients per ha.2/	+0.508*
Crop output/ha. and Total annual rainfall	+0.00003
Crop output/ha. and proportion of rainfall in June-September	-0.312

1/ Throughout the paper ** means significant at 5% level and * significant at 10% level.

2/ Relates only to 11 districts.
The total correlation coefficient between output/ha. and percentage irrigated area for this sub-set is 0.845.**

23. Since some of these explanatory variables are inter-correlated, we fitted a linear multiple regression relating output per hectare to all the explanatory variables to get a more accurate idea of the net effect of each. The estimated regressions are as under:

All districts $Y = 862.5 + 10.48x_1^{**} + 0.14x_2 - 4.75x_3$ R^2 0.419

'T' values = (2.178) (3.778) (0.694) (-1.495)

11 districts $Y = 918.3 + 10.45x_1^{**} - 0.23x_4$ R^2 0.715

'T' values (7.266) (3.583) (-0.087)

Where Y = output per ha; x_1 = percentage of irrigated area;
x_2 = total rainfall; x_3 = percentage of rainfall occuring June-September,
and x_4 = plant nutrient/ha.

The first regression suggests that irrigation is the only variable with a significant net positive effect on yield. The coefficient for seasonal distribution of rainfall, though negative, is not significant. The second shows that though irrigation and fertiliser use taken individually are significantly correlated with yield, the intensity of fertilisation is itself strongly associated with irrigation and hence has an insignificant net effect on yields.[15/]

24. With less than half the observed variation in output/ha "explained" by the selected variables in the full sample, it may be useful to consider what other physical factors might be relevant. We considered two obvious possibilities: First percentage of area under irrigation may not adequately capture the differences in the quality of irrigation. There is clearly a difference between canals and ground water in terms of the degree of control over quantum and timing of water application. Since groundwater makes for better quality of irrigation in terms of the above criteria, it seemed appropriate to see whether the proportion of area irrigated served by wells and tube wells affects yield. Secondly, since the output value per hectare varies a great deal from crop to crop, differences in crop pattern might be a significant determinant of overall production per hectare. But crop-pattern differences cannot be easily quantified into a single numerical index. Moreover, differences in crop pattern are to a considerable extent a function of agro-climatic conditions and irrigation. Pending a much more satisfactory solution to these problems, we decided to use the proportion of cropped area under paddy and sugarcane (which are relatively high value crops and

also quantitatively important) as a possible explanatory variable. The regression for the full sample of 18 districts estimated with these variables and those mentioned earlier gave the following result:

$$Y = 203.2 + 11.2x_1^{**} + 0.18x_2 - 4.39x_3 + 1026.2x_5^{*} + 6.03x_6 \quad R^2 = $$

'T' values =(.421) (3.14) (0.81) (-1.27) (1.92) (1.42)

Where Y, x_1, x_2 and x_3 stand for the same variables as indicated in para 23; x_5 for the proportion of irrigated area under wells and tube-wells; and x_6 for the proportion of cropped area under paddy and sugarca[illegible]

Evidently, the quality of irrigation has a significant influence on productivity. While the proportion of paddy and sugarcane is positively related to total crop yields, the coefficient is not significant.[16]

25. That the selected physical variables still explain less than 60 percent of the inter-district variations in productivity per hectare may appear to cast doubt on our hypothesis regarding the dominance of physical factors in explaining yield. However, such a conclusion would be premature because the specification of the explanatory variables as well as their quantification leaves much room for improvement in several directions: Since the size of the sample is too small, it would be useful to see how the hypothesis fares when tested on a much larger sample. This can be done by (a) including other FMS districts in the Sample (our present sample covers about half the total number surveyed under the FMS), (b) taking individual year observations rather than three year averages, and

(c) data for individual sample farms rather than averages for the sample as a whole. But the problem is not merely one of sample size; we need considerably more refined measures of irrigation quality. The procedure of estimating the quantum of plant nutrients applied (especially in the form of farm yard manures) needs to be improved by getting more reliable estimates of the nutrient content of FYM in different parts of the country. And we need to find more satisfactory ways of incorporating crop-pattern differences in the analysis.

Intra-District Variations

26. In analysing variations in production per hectare within districts, it is not possible, without much more information than is readily available to us at present, to examine the extent to which they are affected by variations in rainfall and its distribution, the quality of irrigation and crop patterns.[17/] All that could be done is to see how differences in proportion of irrigated area and use of fertilisers and manures are associated with productivity differences: The relevant correlation coefficients, given in Table 3, indicate the following: (a) Irrigation and output per hectare are positively associated in 8 out of the 14 districts for which the necessary data were available, but the association is statistically significant only in 2 cases. (b) While the irrigation-yield relation seems much weaker across the farms within districts than across districts, the positive association between the use of manures and fertilisers per hectare and output per hectare is much stronger and more universal than in the inter-district cross-section. The

correlation between the two variables is positive in all cases, and the coefficients are statistically significant at 5% level in 5 cases and 10% in one. (c) The association between irrigation and fertilisation use presents mixed pattern: In 9 cases the association is positive, but it is statistically significant only in 3. The five remaining districts show a negative association between the two variables but the coefficient is significant only in one case.

Table 4

Correlation between output per hectare, Irrigation and Fertilisers in Selected Districts, India

District (1)	No. of observations (2)	Output per hectare and percentage of irrigated area (3)	Output per hectare and manures and fertilisers per hectare (4)	Manures & Fertilisers per hectare & percentage of area irrigated (5)
Pali	8	-0.26	+0.53	+0.08
Raipur	5	+0.15	+0.55	+0.88**
Cudappah	5	+0.38	+0.005	+0.75
Sambalpur	5	-0.76	+0.80	-0.92**
Amritsar-Ferozepur	5	+0.26	+0.64	-0.55
Surat-Bulsar	[illegible]	+0.7[illegible]**	+0.89**	+0.97**
Hooghly and 24 Parganas	8	-0.11	+0.25	+0.77**
W. Godavari (P)1/	8	+0.11	+0.73**	+0.02
W.Godavari (T)1/	8	-0.19	+0.33**	+0.24
Meerut-Muzaffarnagar	7	+0.42	+0.73	+0.67
Cuttack	5	+0.33	+0.93**	-0.04
Coimbatore	5	+0.99**	+0.77	+0.73
Tanjavur	5	-0.60	+0.62	-0.12
Muzaffarnagar	5	-0.34	+0.92**	-0.41

*Significant at 5%.
** Significant at 10%.

1/ "P" stands for Paddy Zone and "T" for Tobacco Zone.

27. The number of observations available for individual districts is far too small to permit multiple regression with even 2-3 explanatory variables. Analysis based on pooling of data for different size-classes of holdings for groups of districts which had been surveyed in the same years,[18] however, seem to confirm that the fertiliser-yield relationship is much stronger than the irrigation-yield relation and also that the association between irrigation and intensity of fertilisation is the opposite of what the inter-district analysis suggests (Table 5).

Table 5

Correlation between output per hectare, Irrigation and Fertilisers in Selected Groups of Districts, India

District Group	No. of observations	Output/ha and percentage of area irrigated	Output/ha and manures and fertilisers/hectare	Manures & Fertilisers per ha. and percentage of area irrigated
A	18	-0.72**	+0.83**	-0.72**
B	16	-0.41	+0.88**	-0.53**
C	9	+0.96**	-0.83**	-0.90**
D	15	+0.78**	+0.30	+0.38
E	20	+0.86**	+0.85**	+0.89**
F	10	-0.34	+0.50*	-0.59**

Group A includes: Amritsar/Ferozepur, Meerut/Muzaffarnagar and Hooghly/24 Parganas.

-do- B -do- : W. Godavari (paddy zone) and W. Godavari (Tobacco zone).

-do- C -do- : Deoria, Muzaffarnagar.

-do- D -do- : Cuddappah, Cuttack and Thanjavur.

-do- E -do- : Surat-Bulsar (based on size-class wise data for 4 zones).

-do- F -do- : Sambalpur (based on size-class wise data for 2 zones).

28. Linear regressions of the per hectare yield (Y) on proportion of irrigated area (x_1) and expenditure on manures and fertilisers (Y_2) for each of the above cross-sections, are given below:

Group A $$Y = \underset{(4.867)}{330.6^{**}} - \underset{(-1.283)}{0.76x_1} + \underset{(3.264)}{9.24x_2^{**}} \qquad \bar{R}^2 \; 1 \; 0.72$$

B $$Y = \underset{(4.222)}{367.1^{**}} + \underset{(0.471)}{0.47x_1} + \underset{(5.943)}{5.74x_2^{**}} \qquad \bar{R}^2 = 0.78$$

C $$Y = \underset{(1.467)}{786.3} + \underset{(4.794)}{15.59x_1^{**}} + \underset{(0.888)}{5.56x_2} \qquad \bar{R}^2 = 0.94$$

D $$Y = \underset{(9.326)}{763.9^{**}} + \underset{(4.053)}{4.58x_1^{**}} + \underset{(0.007)}{0.006x_2} \qquad \bar{R}^2 = 0.62$$

E $$Y = \underset{(8.569)}{500.7^{**}} + \underset{(1.941)}{6.38x_1^{*}} + \underset{(1.660)}{2.85x_2} \qquad \bar{R}^2 = 0.77$$

F $$Y = \underset{(6.148)}{106.90^{**}} - \underset{(-0.172)}{0.09x_1} + \underset{(1.148)}{3.83x_2} \qquad \bar{R}^2 = 0.26$$

Except in Sambalpur, a high proportion of variations in output per hectare is explained by differences in irrigation and fertilisation. The coefficients have generally the expected positive sign (except for irrigation in Group A and F); but the relative importance of the two factors differ widely: irrigation seems to be the dominant factor for three groups, and fertilisers in two. But since the pooling involves districts with very different agro-climatic conditions, and since the analysis does not capture the variations in moisture availability even to the degree achieved in the inter-district cross-section, the significance of these findings is difficult to interpret. At any rate no generalisation seems possible at this stage.

Variations in Human Labour Inputs

29. The FMS reports give data regarding direct human labour input for crop production per hectare of cropped area. They also contain information from which it is possible to estimate the quantum of labour used in the maintenance of draught and milch animals.[19] While we shall be concerned here only with labour used directly in raising crops, it may be of some interest to note the extent of variations in all categories. Aggregate human labour input in agriculture and animal husbandry taken together range from 54 mandays in Ahmednagar to 192 mandays in Surat and Bulsar (Table 6). Between 5 and 13 per cent of the labour is used for maintenance of milch animals. The direct and indirect labour inputs for crop production alone (the indirect labour being the quantum used for maintaining draught animals which are almost exclusively used in activities related to crop production) range from 50 days per ha. to 181 days per ha. Of this, between 7 and 22 per cent represents labour input for maintenance of draught animals. The direct labour use for crop production ranges from 44 to 168 days per hectare.

30. There is a high degree of dispersion in all the three indices of labour use in agriculture within the sample districts. There is also a high positive correlation between the three measures of labour use which suggests that high levels of direct labour use in crop production goes with high levels of overall labour use in agriculture. But the relative proportion of the three components vary quite widely.

Table 6

Intensity of Human Labour Input into Agriculture: Selected Districts

District	Number of human labour days per hectare of cropped area used for		
	Crop production alone	Crop production and maintenance of draught animals	Crop production and Animal husbandry
(1)	(2)	(3)	(4)
Ahmednagar	44.3	50.2	54.2
Nasik	56.1	62.4	67.0
Pali	65.7	75.4	85.1
Surat-Bulsar	168.5	181.2	192.0
Amritsar/Ferozepur	51.0	59.4	65.9
Sambalpur	106.7	126.7	136.2
Cudappah	85.3	94.5	109.9
24 Parganas	112.0	135.7	142.7
Meerut/Muzaffarnagar	93.2	119.1	136.8
Cuttack	101.2	112.1	118.4
Hooghly	146.6	161.0	175.5
West Godavari	124.8	127.2	135.6
Deoria	100.9	120.8	136.7
Ferozepur	60.0	69.0	79.5
Coimbatore	93.4	102.3	110.3
Thanjavur	118.8	N.A.	N.A.
Muzaffarnagar	73.2	79.7	91.0
Sample average	94.2	104.7	114.8
C.V.	0.363	0.358	0.344

Factors affecting Intensity of Human Labour Use for Crop Production

31. Our basic hypothesis, it may be recalled, is that the level of human labour input per unit area is determined by (a) the level of productivity per unit area which is taken to be a proxy for the more fundamental determinants (namely the quality of land, agro-climatic conditions and other physical inputs) of the total energy inputs needed for crop husbandary; (b) the use of energy sources other than human labour; and (c) the relative costs and efficiencies of different energy sources.

Inter-district Cross Section

32. The total correlation coefficients between HLD/ha and the explanatory variables have the expected signs (+0.37 for yield/hectare, -0.23 for animal labour, -0.22 for mechanical power, and -0.95 for the relative cost of human and animal labour) but none of the coefficients are statistically significant. A multiple regression analysis, however, shows that the yield per hectare has a significantly positive, and the quantum of horsepower per hectare a significantly negative, relation to human labour input. The regression coefficient for bullock labour and relative costs of human and animal labour are statistically insignificant. In other words, other things being equal, higher productivity goes with larger human labour inputs, and a higher degree of mechanisation reduces the quantum of human labour use.

The estimated regression is:

$$Y = 116.26^{**} + 0.031^{*} x_1 - 1.94 x_2 - 10.57 x_3 - 267.46^{*} x_4 \quad R^2 = 0.3$$

'T' Values (2.985) (2.104) (1.441) (0.467) (-2.258)

where y = HLD/ha, x_1 = output/ha, x_2 = BID/ha; x_3 = cost of human relative to animal labour and x_4 = horsepower/ha.

33. The selected explanatory variables, however, explain no more tha 40 per cent of the observed variations in human labour input. Apart from the fact that our specification of the relationship and the measure of the input variables may be too crude (this is discussed more fully later in this section), it seems possible that differences in crop patte could be an additional factor. This is because the human labour input per hectare varies a great deal between crops: The available crop-wise labour input data from FMS for the selected districts (Table 7) suggest that, on the average, paddy and sugar cane use significantly more huma per hectare than other crops.

Table 7 : Frequency distribution of Intensity of Human Labour input per hectare for different crops

	Number of mandays per hectare					
	Less than 50	50-75	75-100	100-150	150	To
Paddy	-	3	6	17	2	
Wheat	2	5	3	2	-	
Coarse grains	13	4	5	5	1	
Pulses	7	6	-	-	-	
Groundnut	-	1	1	1	1	
Cotton	-	2	1	1	1	
Sugarcane	-	-	1	4	5	

Source: Compiled from data relating to individual crops given in the FMS reports for selected districts. Since the choice of crops was not based with any idea of getting a representative sample for the cou as a whole, and since no distinction is made between irrigated and unirrigated crops, this distribution is only indicative.

34 While the reasons for these differences are still a matter for investigation, the fact of such differences should perhaps be taken into account in any attempt to explain differences in labour input a across regions and farms. The regression was, therefore, re-estimated by introducing the proportion of area under paddy, and sugarcane as an additional explanatory variable (x_5). While this imposes the R^2 (0.52), the crop-pattern variable turns out to be not so significant afterall; moreover, its introduction makes all other coefficients also statistically non-significant. The estimated regression is:

$$y = 124.5 + 0.014\,x_1 - 2.14\,x_2 - 33.29\,x_3 - 187.05\,x_4 + 0.50\,x_5$$

T values (3.365) (0.787) (-1.604) (-1.232) (-1.423) (1.669)

Intra-district Variations

35. It is impossible to do a similar analysis of intra-district variations because (a) the number of observations available are too few; (b) they are averages for groups of farms which are not homogenous either in terms of the size or composition and (c) the information on mechanical power is not available. For most districts we can only find out the extent to which human labour input is associated with yields, bullock labour and the relative costs of human and animal labour takes individually The results (presented in Table 8) show the following:

(1) Human labour input and production per hectare are positively associated in most (12 out of 14) districts for which data are available. The correlation is statistically significant in 5 cases, and not significant in the other six. Of the three districts where the correlation is negative, the coefficient is significant only in one (Surat-Bulsar).

(2) Unlike in the inter-district cross-section, human labour and animal labour inputs are positively associated in 13 out of 14 districts analysed and the coefficients are significant in 7 cases. There is a significant and negative correlation between the two variables only in the Tobacco zone of West Godavari.

(3) In a majority of districts (10 out of 14) there seems to be an inverse relation between the intensity of human labour input and the relative cost of human to animal labour, but the relation is significant only in three. Though the two variables are positively correlated in 4 districts, the correlation is low and statistically insignificant in all except Cuttack.

Table 8 Correlation Between Human Labour Input and other Variables in Selected Districts

District	No.of observation	Correlation between HLD/ha and		
		Output/ha	BLD/ha	Cost of HL / Cost of BL
Pali	5	+0.86**	+0.27	+0.36
Raipur	5	+0.90**	+0.97**	-0.58
Cuddappah	5	+0.32	+0.97**	-0.64
Sambalpur	5	+0.79	+0.75	+0.65
Amritsar/Ferozepur	5	-0.43	+0.99 **	+0.97**
Surat/Bulsar	5	-0.99**	+0.96 **	-0.98**
Hooghly/24 Pharganas	8	+0.54	+0.52	-0.49
W.Godavari (P)	8	+0.54	+0.51	+0.34
W.Godavari (T)	8	+0.74**	-0.64*	-0.60
Meerut/Muzaffarnagar	5	+0.79	+0.90**	-0.47
Cuttack	5	+0.93**	+0.97**	+0.90**
Coimbatore	5	+0.82*	+0.97**	+0.15
Tanjavur	5	-0.38	+0.91**	-0.02
Muzaffarnagar	5	+0.71	+0.95**	-0.88**

36. The picture is such the same when we pool size-classwise data for different districts or zones within particular district s(Table 9) The intensity of human labour input is positively associated with productivity in 5 out of six cases, and significantly so in 4 of them, as well as with bullock labour use (positive in 5 cases and significant in 3). The coefficient for relative costs is positive in three cases and negative in three, only one of the former being significant.

Table 9 Correlation coefficients between Human labour use and other variables: Groups of Districts (zones)

Group	No.of observations	Correlation between HLD/ha and Output/ha	BLD/ha	Cost of HLD / Cost of BLD
A	18	+0.90**	+0.001	+ 0.55**
B	16	+0.73**	-0.55**	- 0.38
C	9	-0.70**	+0.98**	+ 0.23
D	15	+0.57**	+0.70**	+0.32
E	20	+0.51**	+0.38**	- 0.26
F	10	+0.23	+0.47	- 0.003

Note: The constituent districts/zones of each group are the same as indicated in Table

37. Multiple regression analysis (the results of which are given below) also shows production per hectare (x_1) to be a significant positive influence on labour absorption (Y) in half the groups; the positive relation between human and bullock labour (x_2) is more universal (the only exception is West Godavari). The relative costs of human and animal power (x_3) exerts on significant negative influence on use of human labour in two cases; positive in two others, with the coefficients being

insignificant in the remaining two. The divergent pattern of relation as between the inter-district and intra-district analysis, as well as between different district groups are puzzling and cannot be easily explained.

A	$Y =$	-109.6	$+ 0.183^{**}x_1$	$+ 3.53^{**}x_2$	$+ 83.59^{**}x_3$	$R^2 =$
		(-3.254)	(3.269)	(2.380)	(2.823)	
B	$Y =$	221.13	$+ 0.134^{**}x_1$	$- 3.99^{**}x_2$	$- 98.56^{**}x_3$	$R^2 =$
		(4.059)	(4.836)	(-2.503)	(-2.350)	
C	$Y =$	15.50	$- 0.005x_1$	$+ 3.65^{**}x_2$	$+ 4.52x_3$	$R^2 =$
		$(.141)$	(-0.238)	(3.412)	(0.025)	
D	$Y =$	6.30	$- 0.002x_1$	$+ 2.89^{**}x_2$	$+ 49.6^{**}x_3$	$R^2 =$
		$(.379)$	$(-.078)$	(7.166)	(4.418)	
E	$Y =$	104.15	$+ 0.079^{**}x_1$	$+ 6.12^{**}x_2$	$- 616.2^{**}x_3$	$R^2 =$
		(3.581)	(4.89)	(3.07)	(-3.51)	
F	$Y =$	21.28	$- 0.029x_1$	$+ 2.70x_2$	$- 16.43^{**}x_3$	$R^2 =$
		$(.77)$	$(-.13)$	(1.38)	$(-.70)$	

<u>Relation between Human and Bullock Labour</u>

38. That high levels of human labour use generally tend to go with larger inputs of animal labour has been interpreted as evidence of complementarity between the two sources of energy. But as pointed out above, the positive correlation between the two is neither universal no always significant; in any case it certainly does not imply that they used in fixed proportions. The ratio of human to bullock labour in fac varies very much across districts and within districts (See table 1). The significance of these variations and the factors responsible for them have, however, received hardly any attention in the literature.

39. The data suggests that as the ratio of HLD to BLD rises, the absolute quantum of human labour input per hectare tends to be higher and that of bullock labour to be lower: Thus, when we look at the inter-district cross-section, HLD and HLD/BLD are found to be positively and significantly correlated (+0.80**), while the correlation between BLD and HLD/BLD is negative and significant (-0.73**). The picture, as in other cases, is rather confused when we consider the individual district cross-section: Though the HLD-HLD/BLD correlation is positive in a majority of the districts (8 out of 14), the coefficients are statistically significant only in three. In 6 districts, the correlation is negative but significant only in one case. BLD is negatively associated with HLD/BLD in 13 districts but in 12 of them the coefficients are not statistically significant. However, when we consider groups of districts, the relations are more in line with those found in the inter-district cross-section (Table 10). This is also true when we pool the size-classwise data across all districts.

40. It would seem, therefore, that the intensification of total energy input (in the form of human and animal labour taken together takes place through higher input of human labour rather than of animal labour. This could mean that as the intensity of total energy input rises, the additional inputs are increasingly concentrated in operations which depend primarily on manual labour and where the scope for use of animals is limited. However, since the above relation is not universal, and since we know that, as a matter of fact, several operations permit the use of human and animals power in varying combinations, it is also

Table **Relation Between Human and Animal Labour in Crop Production**

Cross section	No.of observation	Correlation between HLD/BLD		
		HLD/ha	BLD/ha	Cost of HLD/Cos
Inter-District	18	+0.70**	-0.72**	-0.23
Intra-District				
Pali	5	+0.57	-0.63	+0.46
Raipur	5	+0.24	-0.02	-0.45
Cuddappah	5	-0.61	-0.78	+0.17
Sambalpur	5	+0.29	-0.41	+0.66
Amritzar/ Ferozpur	5	-0.73	-0.81	+0.60
Surat/Bulsar	5	-0.20	-0.47	+0.25
Houghly/24 Pharganas	8	+0.80**	-0.10	-0.25
W.Godavari (P)	8	+0.52	-0.47	-0.48
W.Godavari (T)	8	+0.84**	-0.88**	-0.55
Meerut/Muzafarnagar	5	+0.74	-0.38	-0.81**
Cuttack	5	-0.19	-0.41	+0.04
Coimbatore	5	-0.96**	-0.99**	-0.04
Tanjavur	5	-0.35	-0.71	-0.01
Muzafarnagar	5	+0.02	-0.29	+0.26
Cross section for District groups				
A	18	+0.88**	-0.47**	+0.86**
B	16	+0.86**	-0.81**	-0.37
C	19	-0.95**	-0.97**	-0.13
D	15	-0.10	-0.75**	+0.75**
E	20	+0.49**	-0.59**	-0.20
F	10	+0.66**	-0.35	-0.32
All District and size Classes	86	+0.76**	-0.68**	-0.21**

possible that the variations in HLD/BLD may reflect, in part at least, adjustments of this ratio to different relative costs of the two courses of power in different tracts, and possibly also across farms within the same region.

41. Our analysis shows that while the correlation between HLD/BLD and the ratio of the cost of HLD to that of BLD has the expected negative sign both in the inter-district cross-section and in a majority of the districts, the coefficients are, with a single exception,* not statistically significant. Much the same is true of the analysis using data for groups of districts. But when pool the size-class wise information across all districts, there is statistically significant negative association between the ratio of HLD to BLD and the ratio of their unit costs. The relatively low coefficient of correlation (-0.214**) means that though the relative costs of the two sources of power do influence the relative proportions in which human and animal labour used, they explain barely 5 per cent of the variations in the ratio. Obviously other factors are far more important.

42. To sum up. the results of our analysis of productivity and labour use for crop production: the inter-district cross-section for groups of districts seems to corroborate our hypothesis that physical factors (including intensity of fertilisation) are dominant factor in determining crop productivity. However the relative importance of irrigation and fertilisation varies. Moreover, within individual districts the associations between the selected variables are weak and not always in the expected direction. In any case, the fact that a substantial portion of yield variations across districts remains unexplained points to the need for more detailed and refined analysis.

43. Our analysis of variations in human labour use again provides faily good corroboration of our hypothesis though there still remains much scope for refinment. However the intra-district cross section and the cross-sections for groups of districts present a rather different, and more mixed, pattern especially in regard to the relation between human labour on the one hand, and bullock labour and relative cost of the two on the other. This is also true of the association between the ratio of human to animal labour and their relative costs. It is possible that apart from the limited number of observations for individual districts and the inability to include some of the explanatory variables which figure in the inter-district cross-section, the level of labour use both in absolute terms and relative to other forms of energy within particular tracts are also influenced by differences in the quality of land, availability of family labour, access to and relative cost of different energy sources- all of which may be systematically related to the size of holding. These variations, which get averaged out to a larg extent in the inter-district analysis may be much more important in explaining variations between farms within particular districts.[20]

44. Besides the above, the following further general limitations nee to be borne in mind. First, it is possible that the scope for substitution between human and animal power may differ significantly cro to crop and from one operation to another. If this were so, analysis of their use levels aggregated over all operations may not adequately capture the substitution relationship. One should analyse the use of human and animal labour by specific crops and operations.

45. We tried to take the former into account by introducing the proportion of paddy and sugarcane (two of the major, labour-intensive crops) as explanatory variables. But, for reasons mentioned earlier, this is not a wholly satisfactory way to capture the effect of crop-pattern differences. In any case, this could not be done in the case of intra-district cross-sections. As for operation-wise labour use, the published data do not permit an analysis for crop production as a whole; but we shall attempt such an analysis for paddy in the subsequent section.

46. Secondly "mandays" and "bullok-pair days " may not be sufficiently standardised measures of the quantum of effective energy input into agricultural operations. The latter depends not only on the time spent, but also on the body weight and nutritional intake of both humans and animals.[21] That there are substantial variations in both these dimensions across districts is all too obvious. Such variations may also exist within a district as between any well-to-do and poor farmers, especially if the latter tend to be relatively undernourished and carry poorer quality cattle. The problem will be compounded if the extent of variations in effective work output per unit of time varies systematically, but not uniformly, for the two sources of energy as between districts and classes of farmers. There is however, no way of handling this problem with any of the data sources currently available.

47. The third, and perhaps the most important, limitation of our analysis is that variations in the input of human and animal labour cannot be analysed independently of the input of mechanical power

especially because the use of machines (mostly irrigation appliances and tractors) in many of the sample districts have reached signific levels. In the inter-district cross-section analysis we used the st of machines (converted to HP equivalents) per unit of cropped area a one of the variable. However this is too crude a measure because (a) it assumes that the average HP per pumpset or tractor is unifor throughout the country; (b) it does not give an accurate idea of th degree of utilisation of the machines, which is the appropriate inde of work done by them; and (c) it fails to distinguish the fact that different machinery have diffe·ent effects on the requirement of hu and animal labour.

48. The complexity of the last mentioned relation is illustrated by some apparently odd associations found in our correlation analysi For instance, while both HLD/ha and BLD/ha are negatively associated with HLD/ha, only the association between BLD and "LD is statisticall significant; this suggests that machines may tend to displace animal more than human labour. But it is also found that the HP/ha is significantly associated with percentrage area under well irrigation yet the latter shows a strong negative association with HLD/ha and hardly any with BLD/ha. The reasons seems to be that though well irrigation contributes to larger overall productivity, it is associa with crop pattern in which paddy, a labour intensive crop, is relati less important. Such inter-relations cannot be unravelled without f more detailed data and a far larger number of sample observations th is available in a published form. We need to go to the original schdules for each sample farm for getting the necessary detail. We intend to do this in the next phase of work.

The Use of Hired Labour

49. Though not strictly germane to the central theme of the paper, our analysis throws some incidental light on the use of hired human labour in crop production. The proportion of hired to total human labour varies (See Table 1) from around 27 per cent in Amritsar/ Ferozpur (1954-57) to 85 per cent in Coimbatore (1970-73). As might be expected, the amount of hired human labour input increases with the overall human labour input (cc + 0.82**). Both total and hired human labour inputs are positively associated with production per hectare, but the association between hired labour and productivity is much stronger (+0.55**); also the proportion of hired labour to total labour shows a positive, and statistically significant, association with productivity (+0.64**). In other words, areas with higher productivity use more hired labour per hectare not only in absolute terms, but also as a proportion of total labour input. Again while both total and hired human labour are negatively associated with the level of animal labour input, the hired human - animal labour relation is much more pronounced (-0.44**) and, unlike with total human labour (-0.21) statistically significant.

50. The significance of these associations, much less the casual links between the correlated variables, are far from obvious. The inter-district cross-section data show a strong positive relation between output per hectare and output per human labour day (+ 0.75**). The fact that the productivity and proportion of hired labour are positively associated suggests that the incidence of landlessness tends to rise as we move from low to high productivity regions. (Does this

that high productivity districts have less land relative to populati and/or that land is more unequally distributed in them? For we have some independent evidence to suggest that the proportion of wage labour is inversely related to the cultivated area per capita and positively related to the degree of ineuality in its distribution). A larger proportion of landless labour tends to depress wage rates. On the other hand, since areas of high productivity also have relati high output per man day, the competition between humans and animals for land may be expected to be less severe, and hence animal labour to be relatively cheaper, compared to low productivity tracts.

51. There is no apriori basis for judging what the net effect wil in the relation between the relative costs of human and animal labou on the one hand and productivity per unit area on the other. But as a matter of fact, areas of high productivity tend to have a high HLD/ BLD and hired HLD/BLD, and their relative costs bear a strong relati to the latter. This would lead one to expect that in such areas the cost of human labour relative to bullock labour will be low. There i in fact a negative correlation between output per hectare and the relative cost of HLD and BLD but the coefficient (-0.19) is not statistically significant. The same is true of output per man day an the relative cost of HLD and BLD (-0.25). Finally the negative relation between hired labour intensity and BLD/Ha may be indicative of the fact that the adjustments in use of human labour which affect ratio of HLD to BLD take place primarily through hired labour.

52. All this is admittedly rather specultive. It does not take into account the behaviour of participation rate of cultivating and wage labour families, the relative intensities of employment of the two categories of workers, the nature and scale of activities other than crop production and the use of power in forms other than human and animal labour. But the surprisingly consistent patterns revealed by the data warrant much closer study.

III

Productivity and Labour Use: Paddy

53. Data relating to average yields, in input of manures and fertilisers, as well as of human and animal labour and their relative unit costs in respect of paddy for 12 districts are presented in Table 11.

Table 11: Yields and Inputs for Pddy in Selected Districts

District	Zone/crop	Yield kg/ha	Nutrient Kg/ha	HLD per ha	BLD per ha	Hired HLD per ha	Cost of / Cost of
Cuddappah	I	2224	64.0	143.7	38.3	99.6	.573
Surat-Bulsar	I and UI	1369	59.5	139.4	13.4	87.3	.133
Deoria	I Early UI	1209	75.0	85.8	17.2	39.4	.261
	2 Late UI	740	34.0	65.1	13.5	37.6	.276
Tanjavur	1 Kuruvai	2932	244.0	141.5	29.4	110.2	.989
	2 Samba	2332	145.0	129.6	31.4	97.5	.985
	3 Samba	2408	184.0	138.0	32.2	92.2	1.079
	4 Thaladi	2069	73.0	116.0	23.1	92.5	.934
	5 Thaladi	2229	57.0	134.3	23.9	102.4	1.07[illegible]
Coimbatore	1 Canal I	2990	135.0	173.2	23.3	155.2	.416
	2 Well I	3383	131.0	167.3	21.5	132.0	.325
Ferozepur	I and UI	2407	55.0	78.9	9.7	50.1	.385
Cuttack	I and UI	1576	11.2	113.6	33.7	51.5	.550
Sambalpur	I and UI	1165	8.2	101.2	30.2	42.0	.538
W.Godhavari (P)	Ist season						
	2nd season	1953	n.a	110.2	19.7	83.4	.218
(T)	"	1617	n.a	120.4	19.5	[illegible]	.404
(All)	2nd season	2262	n.a.	117.4	19.9	94.8	.272
Muzaffarnagar	I and UI	2228	n.a.	70.0	12.0	42.0	.235
Hooghly	1 Aman I & UI	1631	10.3	130.5	25.3	57.9	1.139
	2 Aus I & UI	1170	31.5	127.7	23.1	23.2	1.238
24 Parganas	1 Aman I & UI	1413	2.1	112.0	21.0	36.5	.937
	2 Aus I & UI	1456	13.6	126.0	26.3	27.9	.920

Source: FMS reports for various districts. Figures usually three year av

Note: I = Irrigated UI = Rainfed

Tanjavur 1,2 and 4 relate to HYV. In other cases varieties are no specified. But in most cases, since data relate mid - or late fitie the data presumably relate to local varieties.

In an effort to enlarge the number of sample observations for analysis, we have taken, wherever possible, data for different reasons and varieties within each district. While this nearly doubles the number of sample observations overall, the increase is not uniformly distributed between districts: The major part of it is concentrated in Tanjore (4) and W.Godavari (3). Moreover, compared to the data for all crops, the paddy sample is much less representative of the diverse conditions under which it is grown: In a majority of cases, the data relate to irrigated paddy; a few relate to rainfed cultivation; while others give an average for irrgated and rainfed crops. The pooled data for seasons/zones within particular districts - and this was possible only in four cases namely, Tanjore (seasons), Surat-Bulsar (zones) and West Godaveri (zones and seasons) - are perhaps more reliable in that they relate to regions which are rather more homogeneous in terms of agro-climatic conditions. In evaluating results of our analysis and the conclusions drawn from them, the possible distrortions introduced by the above factors need to be constantly kept in view.

<u>Relation between Yield and Physical factors</u>:

54. Since the extent of dispersion of the values relating to the proportion of area irrigated is quite small in the sample data and since in the few districts (zones), where the intensity of irrigation evidently varies within the sample, the data on the proportion of paddy area under irrigation in different size-class of holdings are not available, it is not possible to test the irrigation-yield association from the sample data.

55. Average paddy yield across districts* show a high and significa[nt] positive correlation with the intensity of fertilisation (measured by the quantum of plant nutrients per hectare in the form of both manures [and] fertilisers). About 50 per cent of the variation in paddy yields in [the] inter-district cross-section seem to be accountable by this factor alone. But this is not the case when we consider the variations withi[n] districts: Of the 16 seasons and zones for which relevant data are available, the correlation between paddy yield and expenditure on manures and fertilisers per unit area has a positive sign in 9 cases, but of these only 3 are statistically significant. The pooled data f[or] different zones/seasons within the same districts shows a positive and significant relation between yields and fertilisation in Tanjavur and Surat-Bulsar; the relation is positive and non-significant in West Godavari and negative and non-significant in Coimbatore. The weakness of the association between fertilisation and yields within districts [is] contrary to expectation. It is difficult to say whether this is an accurate reflection of reality or is the result of lack of homogeniety [in] the sample in respect of the relevant physical factors which have a bearing on fertiliser response.[24]

56. In any event the data are clearly inadequate for a satisfactor[y] test of the importance of the physical-biological factors in determin[ing] paddy yield. We have been unable to capture not only the variations [in] irrigation and the intensity and distribution of rainfall, but also

* Throughout the subsequent discussion 'districts' or "interdistrict cross section" refer to observations for zones and seasons within each district also.

other factors like the variety of seed used, drainage conditions, availability of sunlight, and duration of the crop. These latter set of factors, which are known to significantly affect paddy yields, are highly variable across regions and, in some cases, also across farms. The relevant information regarding them does not seem to be available even in the detailed schedules relating to individual sample farms covered by the FMS. The cost of Cultivation Studies[25] and the Sample Surveys of High Yielding Varieties conducted by the Institute of Agricultural Research Statistics[26] (IARS) do collect such data and should permit a much more satisfactory analysis of these relationships.

Variations in Human labour inputs:

57. The input of human labour for paddy cultivation in the selected districts ranges from around 65 mandays per hectare for rainfed, late varieties in Deoria to over 170 mandays for the crop irrigated by wells in Coimbatore. There is a significant positive correlation (See Table 12) between the intensity of human labour on the one hand yields per ha and BLD/ha, across the districts. The correlation with the relative cost of human and bullock labour is also positive but weak. For individual districts/zones/seasons also human labour input is in general positively associated with yields and the use of animal labour, but in a majority of cases the coefficients are not statistically significant. Pooling size-class wise data for seasons/zones, which was possible in four cases, shows a similar picture to the inter-district cross section except in Coimbatore where HLD was a weak negative relation to yield and to cost of HLD/BLD

and West Godavari where HLD - BLD correlation is negative (again not significantly). That the strength of these relations varies a great deal even within the same district as between seasons and varieties (e.g. Thanjavur) or the source of irrigation (coimbatore) points to the complexity of the relations involved

Table 12: Relation between Human Labour Input and Selected Variables: Paddy

Crop		Correlation coefficients between HL		
		Output	BLD/ha	Cost of [illegible] / Cost of [illegible]
Inter District Cross Section		+0.50	+0.49	+0.32
Individual District				
Hooghly/24 Parganas	Aman	+ 0.35	NA	NA
	Aus	+ 0.88**	NA	NA
W.Godavari (P)	First	+ 0.43	+0.45	NA
(T)	First	+ 0.66**	-0.05	NA
	Second	+ 0.56	+0.16	NA
Sambalpur		+ 0.72 *	+ 0.90**	NA
Surat Bulsar		+ 0.53	-0.004	NA
Deoria	Early/Late	+ 0.66*	+0.77**	-0.26
Tanjavur	1	+ 0.69	+0.73	NA
	2	+ 0.19	+0.95**	NA
	3	+ 0.01	-0.26	NA
	5	+ 0.82*	+0.82*	NA
Cuddappah		- 0.07	+0.73	-0.66
Coimbatore	Canals	+ 0.22	+0.50	NA
	Wells	- 0.78	+0.66	NA
Muzafarnagar		- 0.24	+0.43	NA
Ferozepur		- 0.26	+0.52	NA
Cuttack		+ 0.98**	+0.98**	NA
Grouped Data				
W.Godavari	2 zones 2 seasons	+ 0.50**	-0.11	+0.31
Tanjavur	Kuruvai Samba Thaladi	+ 0.36	+0.50**	+0.20
Coimbatore	Canal & Wells	- 0.27	+0.43*	-0.27
Surat Bulsar	4 zones	+ 0.69**	+0.28	-0.16

58. The correlation between human labour input and its unit cost relative to that of animal labour presents a mixed pattern: In the inter-district cross-section, they are positively correlated and significantly so. For grouped data the coefficients are positive in two cases, and negative in two others; all but one (in Coimbatore, where the coefficient is negative) are not significant.

59. On the strength of these total correlation coefficients it would seem that human labour input is generally an increasing function of yield, as also of animal labour input. The relation of human labour use to the relative cost of the two sources of power is even less clear. Multiple regression of HLD on the three explanatory variables broadly confirms this: In the inter-district cross-section, and the pooled data for three of the four districts analysed, the coefficient for yield is positive and highly significant; the coefficient for bullock labour is also positive in all cases, but is significant only in two. In both respects the relations follow a pattern similar to that observed for all crops. But unlike in the latter, and contrary to expectation, there seems to be a tendency, though not always significant, for more human labour to be used even when it is more expensive relative to animal labour. If the season-wise data by size classes for all four districts are pooled, the results are markedly different: While the quantum of human labour input is a strongly increasing function of animal labour, the coefficient for yields per hectare becomes weakly negative. Moreover, unlike in the individual district cross-sections, the pooled data show that as the cost of human labour relative to animal power rises there is a tendency (not always significant for the quantum of human labour input to fall. One is left rather puzzled by these disparate results.

Interdistrict	(22)	$Y = 43.55 + 0.021x_1^{**} + 1.273x_2^{*} + 9.265x_3$ (2.328) (3.02) (1.779) (0.621)	$R^2 = 0.50$
Surat-Bulsar	(20)	$Y = 38.61 + 0.033x_1^{**} + 3.16x_2 + 10.22x_3$ (.22) (2.737) (1.666) (1.262)	$R^2 = 0.56$
West Godavari	(24)	$Y = -1.09 + 0.015x_1^{**} + 0.718x_2 + 7.08x_3^{**}$ (-0.059) (3.050) (0.591) (2.082)	$R^2 = 0.38$
Thanjavur	(20)	$Y = -14.07 + 0.018x_1^{**} + 2.11x_2^{**} + 9.09x_3^{**}$ (-0.499) (2.612) (4.829) (4.028)	$R^2 = 0.67$
Coimbatore	(10)	$Y = 79.90 - 0.007x_1 + 2.62x_2 + 3.58x_3$ (.249) (.142) (.550) (.124)	$R^2 = 0.18$
Pooled data	(74)	$Y = 65.95 - 0.0004x_1 + 3.81x_2^{**} - 5.62x_3^{**}$ (4.261) (-0.047) (6.243) (-1.464)	$R^2 = 0.44$

Y = HLD/ha, x_1 = yield/ha, x_2 = BLD/ha, and x_3 = cost of HLD/cost of BLD.

Note: Figures in brackets before Y refer to the number of observations in each case; those in brackets below each regression coefficient gives its 'T' values.

60. The proportion hired to total human labour input in paddy cultivation varies from around 18 per cent for the aus crop in Hooghly to around 80 percent in Coimbatore, Thanjavur and parts of West Godavari. Both in the inter-district cross-section and the pooled data for the 4 districts the use of hired labour increases with per hectare yields (x_1), the increase being substantially higher than for total labour input. The latter suggests that the proportion of hired to total labour increases with yields. However this relationship is not as marked in individual districts. The coefficient is significant and positive only in one case (Thanjavur). Again while the inter-district and pooled intra-district cross-section show a tendency for hired human labour to rise with bullock labour use (x_2), the relation is less striking and consistent in the intra-district cross-section taken individually. In all cases the use of

hired human labour (Y) increases even as the relative cost of human to animal labour (x_2) rises.

$$\text{Surat-Bulsar} \quad Y = \underset{(-3.10)}{46.98} + \underset{(1.70)}{0.019x_1} + \underset{(3.64)}{0.51x_2^{**}} + \underset{(4.63)}{3.25x_3^{**}} \qquad R^2 = 0.92$$

$$\text{West Godavari} \quad Y = \underset{(2.35)}{24.17} - \underset{(0.889)}{0.004x_1} + \underset{(1.421)}{0.257x_2} + \underset{(1.095)}{0.849x_3} \qquad R^2 = 0.137$$

$$\text{Thanjavur} \quad Y = \underset{(0.090)}{1.978} + \underset{(3.264)}{0.020x_1^{**}} + \underset{(0.714)}{0.099x_2} + \underset{(4.562)}{3.253x_3^{**}} \qquad R^2 = 0.73$$

$$\text{Coimbatore} \quad Y = \underset{(0.819)}{59.21} - \underset{(-1.673)}{0.026x_1} + \underset{(1.544)}{0.389x_2} + \underset{(7.860)}{4.887x_3} \qquad R^2 = 0.91$$

$$\text{Pooled} \quad Y = \underset{(-4.60)}{-25.31} + \underset{(2.43)}{0.0056x_1^{**}} + \underset{(13.04)}{0.488x_2^{**}} + \underset{(10.72)}{3.456x_3^{**}} \qquad R^2 = 0.92$$

61. As in the case of all crops, the ratio of HLD to BLD varies over a wide range both across and within districts. There is no significant or consistent relation between level of human labour input and the ratios of human and animal labour; the coefficient signs for the inter-district cross-section and grouped data for seasons and zones in three districts are yield positive, but significant only in two cases. However, in all cases the association between the level of animal labour and the ratio of human to animal labour is strongly negative. This would seem to suggest that a higher ratio of human to animal labour may go with higher or lower absolute level of human labour input per hectare, but the former almost invariably goes with a smaller absolute input of animal labour (Table 13).

Table 13

Relation Between HLD/BLD and their relative costs

	Correlation coefficient between		
	HLD and HLD/BLD	BLD and HLD/BLD	$\frac{HLD}{BLD}$ and $\frac{\text{cost of HLD}}{\text{cost of BLD}}$
1. Inter-district	+0.20	-0.69**	-0.43**
2. West Godavari	+0.47**	-0.83**	-0.50**
3. Tanjavur	+0.05	-0.82	-0.003
4. Surat-Bulsar	+0.55**	-0.63**	+0.012

62. Across districts the variations in HLD/BLD ratio for paddy seems to be somewhat more sensitive to the relative cost of the two sources of power than in the case of all crops: When we consider the pooled intra-district cross-section, the correlation between HLD/BLD and their relative costs have the expected negative sign in all three cases, but the coefficient is statistically significant only in one case.

63. In sum, our analysis seems to corroborate the Ishikawa hypothesis that in general the intensity of human labour input tends to rise as yields per hectare increases. But the relation does not hold in all cases, nor is it always as strong as one might expect. We have found that the relation seems to hold better when we consider inter-district variations than variations within districts, probably for the same reasons as indicated in the discussion of the results for all crops. It is also possible that there are systematic differences in labour requirement for different varieties of paddy, and for different seasons. Furthermore, the relation between human and animal power do not seem to follow any consistent pattern: A more satisfactory analysis of the determinants of human labour use, and explanations for some apparently puzzling results, will have to await a variety specific, season specific analysis of individual farms, taking explicit cognisance of the use and effect of different kinds of mechanical power.

Analysis of human and animal labour use by operation:

64. While most of these variables cannot be incorporated in the present analysis, it is possible to examine the extent to which the overall intensity of human labour use is the result of systematic differences in the use of human and animal labour in different operations. The data regarding the distribution of human and bullock labour by different operations in the sample districts are presented in Table 14 (Table 14)

65. They reveal the following broad pattern: (1) The bulk of human labour is used in land preparation, sowing, harvesting and threshing. (2) inter culture absorbs significant amounts of labour in some regions and some regions; and (3) Bullocks are used primarily in land preparation and in harvesting/threshing, though the relative proportion of animal days spent on these varies a great deal. Hardly any animal power is used in other operations.

66. The extent of variations across districts as well as within districts (Table 15) in the input of human labour per hectare is fairly low both in harvesting/threshing and in land preparation and sowing. The coefficients of variation for these two sets operations taken together are, however, lower than when takes individually: It is suspected that this may be due at least in part to the lack of rigorous definition of the components of each of these operations. In all other operations, the human labour input per hectare is highly variable.

Table 14

Use of Human and Animal labour for Paddy cultivation by operations: Selected Districts

	Prepa-ration (1)	Sow-ing (2)	Manu-ring (3)	Irri-gation (4)	Inter-culture (5)	Har-vest (6)	Post-havest (7)	Others	Total
Monghyr North	14.8	8.3			11.1	24.7	7.4		66.3
	14.5					0.1	7.2		21.[illegible]
Monghyr Central	22.6	33.4	0.7	1.7	7.9	21.4	12.9		100.7
	19.0	0.5					2.5		22.[illegible]
Monghyr South	24.1	26.8	0.1	1.5	4.6	23.7	11.3		[illegible]
	24.3	0.1					9.2		33.[illegible]
Surat-Bulsar	9.1	36.8	6.3	1.7	23.0	51.7		11.3	139.[illegible]
	6.4		2.3		0.3	3.6		0.7	13.[illegible]
Sambalpur Aman	18.5	6.9		1.1	43.1	24.5	7.0		101.[illegible]
	12.9	4.7			4.2	0.9	7.5		30.[illegible]
24-Parganas Aman	18.8	27.9		0.7	13.8	27.7	23.0		111.[illegible]
	na	na		na	na	na	na		21.[illegible]
-do- Aus	19.0	10.1			48.7	26.4	21.7		126.[illegible]
	na	na			na	na	na		26.3
Hooghly Aman	24.0	29.7		1.5	19.0	29.4	26.9		150.5
	na	na		na	na	na	na		25.[illegible]
Hooghly Aus	19.8	16.8			47.7	23.5	18.8		126.5
	na	na			na	na	na		[illegible]
W.Godavari(T)I-1	15.3	23.3	5.2	5.9	24.5	28.3	15.9	2.9	121.[illegible]
	11.5	1.7					5.7	0.3	19.[illegible]
W.Godavari (T)UI	9.4	2.1	3.9		46.6	24.2	13.6	1.9	101.[illegible]
	5.0	0.7	1.1		0.5	.02	1.9	0.1	[illegible]
W.Godavari(P)I-1	18.5	22.9	4.1	3.5	17.1	24.2	22.4	2.5	[illegible]
	9.9	1.6					8.1	0.4	19.[illegible]
W.Godavari(P)I-2	21.7	20.7	5.8	7.2	14.0	20.8	18.4	1.7	[illegible]
	12.2		0.8				6.4	0.3	19.[illegible]
Deoria UI-E	18.2	9.8	2.2		22.5	19.8	13.7		[illegible]
	8.7	3.2	0.4		0.6		4.3		17.2

Contd...51/-

Table 14 contd.

	Prepa-ration	Sow-ing	Manur-ing	Irri-gation	Inter-culture	Har-vest	Post-harvest	Other	Total
	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
Deoria UI-L	13.7	16.3	1.0		17.6	9.8	6.7		65.1
	7.7	2.7	0.2		0.2		2.7		13.5
Ferozepur I	10.8	16.2	1.6	16.6	7.2	16.1	9.6	0.4	78.4
	7.3	0.2	0.07	0.01				0.2	8.0
Coimbatore CI	24.2	31.7	5.3	24.0	23.9	63.3		0.7	173.2
	17.3	0.4	1.5	0.1		4.0		-	23.3
Coimbatore WI	25.8	30.0	5.9	27.2	21.6	55.4		1.4	167.3
	15.3	0.6	1.4	0.8		3.4			21.5
Muzaffarnagar I	8.3	11.0	0.3	4.6	16.8	15.5	12.6		69.6
	7.5	1.7	0.4	0.2			2.2		13.0
Tanjavur									
1. K-ADT27	41.6	28.7	9.9	4.4	20.7	32.8		3.4	141.5
	23.0		2.8			3.6			29.4
2. S-CO-25	47.2	31.8	6.7	2.2	11.8	27.9		2.2	129.6
	23.6		3.3			4.5			31.4
3. S-Local	42.6	37.3	9.2	4.3	16.1	24.4		3.9	138.0
	23.0		2.9			6.3			32.2
4. T-CO25	27.6	28.2	6.1	4.3	17.3	28.2		4.2	116.0
	18.3		0.2			4.5			23.1
5. T-Local	33.6	28.6	12.1	4.6	16.0	32.9		6.6	134.3
	17.9		0.2			5.8			23.9

First row in each district relate to HLD/ha.
Second -do- -do- BLD/ha.

67. While as a rule, both animal and human power are used for land preparation and harvesting/threshing, their relative proportions vary a great deal not only across districts but within districts. The use of animals for other operations is not universal: Some districts and classes of farms seem to use exclusively human labour, while others use it in combination with animals. The variations in the ratio of the two sources of power in these operations is naturally much greater than in land preparation and harvesting/threshing.

68. The coefficient of variation in bullock labour per hectare for land preparation (both across districts and within districts) is in general smaller than for human labour; but the reverse is true in the case of harvesting and threshing. The variations in bullock labour use for other operations is highly variable. The extraordinary viability in the quantum of human and animal labour used in the "miscellaneous" category may be due in part to misclassification, but it also raise some doubts whether their use in post-threshing operations (winnowing, bagging, transport etc.) are fully and uniformly captured in all cases.

Factors contributing to variations in overall labour use:

69. Before analysing the factors underlying variations in labour use in specific operations, it may be useful to know how much of the variations in aggregate labour input per hectare is attributable to variations in specific operations, and how much to variations between operations. More than half the total variance in the intensity of labour use in the inter-district cross-section

Table 15

Operationwise Distribution of Human and Animal Labour use for paddy

	Preparation (1)	Sowing (2)	Manuring (3)	Irrigation (4)	Interculture (5)	Harvesting (6)	Threshing (7)	Other (8)	Total (9)
Averages for 29 districts									
Human labour/ha:									
Average	22.38	22.54	4.35	5.74	19.16	28.48	7.58	2.12	112.4
CV	.497	.458	.795	1.318	.531	.463	.939	1.277	
Animal labour/ha	14.27	0.90	0.88	0.06	0.27	1.66	3.07	0.10	[illegible]
CV	.430	1.432	1.241	3.226	3.451	1.354	1.025	1.844	
Surat-Bulsar									
HLD/ha Average	10.08	34.93	6.89	1.91	27.53	50.17		10.73	[illegible]
CV	.423	.296	.524	.749	.460	.190		.799	
BLD/ha. Average	6.32	0.00	2.42	0.02	0.48	3.05		0.68	[illegible]
CV	.230	0.00	.521	4.359	1.266	0.440		0.787	
Tanjavur									
HLD/ha. Average	38.85	31.56	10.30	4.52	16.07	29.65		4.22	[illegible]
CV	0.221	0.145	0.498	0.482	0.266	0.163		0.576	
BLD/ha. Average	21.20	0.00	1.82	0.00	0.00	5.06		0.00	[illegible]
CV	0.176	0.00	0.935	0.00	0.00	0.234		0.00	
West Godavari									
HLD/ha. Average	8.06	9.44	1.90	3.01	8.17	10.15	8.07	1.08	[illegible]
CV	.199	.202	.395	.903	.530	.231	.252	.904	
BLD/ha Average	4.24	0.00	0.95	0.00	0.00	0.00	2.63	0.16	[illegible]
CV	.292	0.00	1.747	0.00	0.00	0.00	.347	.888	

CV = Coefficient of Variation.

* Figures are per acre. In all other cases they are per hectare.

and upward of 70 per cent in the case of Surat-Bulsar, Tanjavur and West Godavari is due to differences in the volumes, i.e., in labour use between regions and size classes. The proportion accounted by differences across rows (i.e., between operations) is negligible, and are generally much smaller than the variance due to "errors" (Table 16).

Table 16

Analysis of variance in Human labour input for paddy

	Variance due to			Total
	Rows	Columns	Error	
All districts	2412.6 (1.28)	17852.62** (31.17)	13171.43	33436.67
SB	14.45 (.0265)	18670.65** (108.4)	3271.85	21956.96
Tanjavur	477.62 (1.47)	16477.14** (109.9)	1949.36	18904.12
West Godaveri	454.32 (5.40)	2202.4** (86.0)	589.0	3245.78

Note: - Figures in brackets are 'F' values.

Variations of Labour use in different operations:

70. For analysing the operation-wise variations in labour use, we have grouped the operations into the following categories: (1) land preparation; (2) land preparation and sowing, (3) manuring, irrigation and inter-culture, (4) harvesting and threshing and (5) harvesting, threshing and others.

Land Preparation

This covers a variety of activities such as ploughing, levelling and bunding. The total energy input required for this set of operations will vary depending on the relative importance of these components (which in part is a function of agro-climatic conditions), the number of times each operation is done, as well as physical conditions of the soil (its hardness and depth). The extent of human labour input will depend on the quantum of animal and mechanical energy used, which in turn is a fuction of their relative costs. But we do not know how precisely these elements affect the total energy input into these operations to be able to specify the functional relationships. Even if that were possible, we simply do not have the relevant information in the body of data used for the present analysis to take them into account. The only thing we can do now is to see whether the input of human labour in land preparation bears any systematic relation to bullock labour.

The results, summarised in Table 17, show the following:
(1) Contrary to what we might expect on the basis of casual observation, there is no strict complementarity between human and bullock labour even in land preparation. The ratio of human to bullock labour range from less than unity to over 2 in the inter-district cross-section; the range is even wider within districts for which we have data.

Table 17

Relation between human labour use in Preparatory and Sowing and related variables

	Correlation Coefficients between						
	HLD -HLD/BLD	HLD BLD	HLD BLD yield	HLD-Cost of HL/BL	HLD/BLD Cost of HLD/BLD	HLD yield	BLD yield
Inter-district cross-section							
1.	+0.41	+0.87	+0.28	+.77	+0.52	+0.48	+0.30
2.	+0.36	+0.78	+0.26	na	na	+0.53	+0.24
Surat-Bulsar							
1.	+0.86	-0.05	+0.38	+0.30	+0.28	+0.30	-0.23
2.	+0.81	-0.25	+0.54	n.a	na	+0.66	-0.23
Thanjavur							
1.	+0.55	+0.87	-0.03	-0.50	-0.12	+0.55	+0.71
2.	+0.09	0.84	-0.39	na	na	+0.54	+0.71
West Godavari							
1.	+0.18	+0.35	+0.61	-0.12	-0.57	+0.24	-0.43
2.	+0.25	+0.22	+0.57	na	na	+0.27	-0.43

1 -- Preparatory tillage.

2 -- Preparatory tillage and Sowing.

(2) There is a high positive correlation between human and bullock labour in land preparation, across the sample districts and within Tanjavur; the association is not significant in Surat-Bulsar and West Godhavari.

(3) In general it would seem that, as in the case of all crops and aggregate labour use, human labour input for land preparation in paddy tends to be higher as the ratio of HLD to BLD rises, but the relation is not always significant.

(4) There is no clear or consistent relation between the relative costs of human and bullock labour and the ratios of these two inputs in land preparation. The relation is positive and significant in the inter-district cross-section, positive and weak in Surat Balsar, and negative and non-significant in Tanjavur. Only in West Godhaveri does it conform to expectations of a negative relation. However since this does not take into account the use of machinery, which is bound to affect both human and animal labour inputs, the results remain inconclusive.

(5) The intensity of human labour use in land preparation seems to be positively associated with yield of paddy in all cases though not always significantly.

(Table 17)

71. The BLD-yield relation, however, shows a mixed pattern: the association is positive in 2 cases (significant in Tanjavur) and negative in 2 others (significant in West Godhaveri). And it would seem that in some cases at least the higher the ratio of human

to animal labour, the higher tend to be the yield. If our concept of the determinants of crop yields is correct, these associations would seem to be essentially statistical and not indicative of a casual relation.

72. Apart from the fact that the coefficients are not always statistically significant, it is probable that the tatistical associations are reflective of more fundamental physical factors such as differences in the physical-climatic conditions,determining the yield potential of paddy across regions and even within regions. In other words regions and farms with better quality land (in terms of depth and texture, of soil, moisture condition, and drainage) are capable of producing more and therefore makes it worthwhile for farmers to s[illegible] greater effort in land preparation. The rather mixed picture of ass[illegible] ciation between (a) human and animal labour, and (b) their relative proportion on the one hand and yield on the other, underlines the complexity of the relations involved and, of course, the necessity to explicitly incorporate mechanical power in the analysis.

Land preparation and sowing

73. Unlike land preparation, bullocks are not used to any significant extent in sowing; it is done predominantly by manual labour. The human labour input for sowing is likely to be much higher when paddy is transplanted, than when it is broadcast. The differences would be accentuated if, along with transplanting, farmers also pay greater attention to the proper alignment of the rows and to spacing

between plants. As with the intensity of land preparation, the choice of sowing technique is also likely to be influenced by the agro-climatic and soil conditions which have a major bearing on potential yields. But it is not possible to systematically verify any of these hypothesis with the FMS data. Given the possibility of misclassification of labour use as between preparation and sowing, we only examined the variation in the use of human and animal labour in the two operations taken together. The results by and large corroborate those relating to land preparation taken by itself.(Table 17)

Manuring, Irrigation and Inter-culture

74. All these operations, except irrigation, are almost exclusively carried out by human labour. The labour input for manuring will depend on the volume of material applied rather than on the quantum of plant nutrients applied because of large variations in the nutrient content per unit volume of different fertilising materials. In general since the nutrient content of organic manures is very low, one would expect the labour use in this operation to be determined primarily by the quantum of bulky farm yard manure applied. The labour input for irrigation is liable to large variations depending as it does on the source of water (it takes less work to use canal water than water from wells) and the technique (the labour requirements per unit water applied is much less for farms using pumpsets and tube wells than those using bullocks operated or manual water lifting devices). Labour input in inter-culture is a direct measure of the intensity of weeding effort, though the use of bullock or tractor operated

weeding equipment, and/or chemicals, could affect the extent of human labour input per weeding operation.

75. Again, lack of data precludes any analysis of the relative importance of the above factors in explaining the observed variatio in the human labour input in these operations. But since all these operations are related to physical inputs and their efficiency, whi together have a crucial bearing on eventual crop yields, one would expect a positive association between the intensity of labour input in these operations and yields.

76. Our analysis, however, shows that: (a) The intensity of labo input in manuring is positively associated with yields in 3 cases (the coefficient being significant in 2), while in one the association is weakly negative. (b) Contrary to expectations, the relati between intensity of labour input in inter-culture and yield is ins nificant except in Tanjavur. (c) Where, as in Tanjavur, we find a negative association between labour use for manuring and yield, the inter-culture yield relation is positive, while in the inter-distri cross-section and Surat Bulsar the opposite is true. (Is this patt of any significance in offering clues about the relation between manuring and weeding?) (d) The relation between labour input in all three operations and yield has the expected positive sign in all cases but is significant only in 2.

Table 18

Relation between labour use in Manuring, Irrigation and Inter-culture, and Selected variables

	Correlation coefficients between			
	HLD_m & yield	HLD_w & yield	$HLD_{m,i,w}$ yield	$HLD_{m,i,w}$ HLD
District cross-section	+0.61**	-0.10	+0.51**	+0.65**
Surat-Bulsar	+0.41**	-0.06	+0.11	+0.41**
Tanjavur	-0.19	+0.71**	+0.22	+0.65**
West Godhavari	+0.23	+0.17	+0.38	+0.91**

m - manuring ; w - inter-culture ; i - irrigation

Harvesting and Threshing

76. Harvesting of paddy is wholly a manual operation unaided by bullocks or machines. Bullocks are widely used in conjunction with human labour for threshing but the proportion varies a great deal. The winnowing of threshed grain, their bagging and the transportation of grain and straw also require human labour, and, in the case of transportation, bullocks. As mentioned earlier, there is some doubt whether the post-threshing operations are fully captured in all the survey households. Prima facie the labour use for harvesting per se, seems likely to be more a function of area than yields. If this were so, labour days for harvesting a unit area should be much less variable across farms and districts. This is however, not fully borne out by the data. The level of yield may therefore also be a factor. The latter could affect harvest labour requirements to the

extent that higher yields also go with higher plant density per unit area (which in effect means that the harvester has to cut and stack more stalks per unit area). Perhaps too the thickness of the plant stalks, which can vary with the seed varieties, can make a difference. On the other hand, the work involved in threshing is more a function of the volume of harvested material, and hence of yield, than of area; and since the operation uses both animals and human labour, the input of the both will be influenced by the extent of animal labour used in the operation.

77. The FMS do not always record the labour input with the two operations separately. In some cases the data distinguish between harvesting and post-harvest operation, and there is doubt whether the scope and definition of the operations are strictly comparable across the sample districts. For these reasons, we consider variations in the total human labour use for (a) harvesting and threshing taken together and (b) for harvesting, threshing and other operati the last being assumed to cover all post-threshing operations.

Table 19

Relation between Labour use Harvesting, Threshing and others operations, and yields

	Correlation coefficients between					
	HLD_{ht} yield	BLD_{ht} yield	HLD_{ht} BLD_{ht}	HLD_{htm} yield	BLD_{htm} yield	HLD_{htm} BLD_{htm}
Inter-District Cross section	+0.37	-0.23	+0.09	+0.38	-0.24	+0.13
Surat Bulsar	+0.49	-0.06	-0.15	+0.64	+0.06	+0.26
Tanjavur	+0.26	+0.01	-0.34	+0.18	+0.01	-0.28
West Godhavari	+0.53	+0.17	+0.17	+0.47	+0.19	+0.19

78. As expected there is a positive and generally significant association between human labour input into these two groups of operations and yields. There is no uniform or significant relation between the intensity of bullock labour input and yields. There is also considerable variation in the relative proportion of the two sources of labour. While,in harvesting and threshing. there is no significant relation of complementarity or substitution between human and animal labour across districts and within West Godhavari, higher input of human labour seems to go with smaller inputs of bullock labour in Surat-Bulsar and Tanjavur. When we take all three operations together there is no significant relationship at all. This may reflect incomplete and non-uniform coverage of post-threshing operations; but one needs to scrutinise the primary schedules before anything definite can be said on this question.

79. From the foregoing analysis, a number of questions can be possed for further study: (1) What are the reasons for the sizeable variations in the ratio of human to animal labour in land preparation: Is it largely accounted by the conditions of soil and moisture availability at the time of preparation or does it reflect differences in the quality of bullocks, in the extent of tractorisation and/or differences in the relative endowments of family and owned-animal labour as between farms of varying sizes? (2) Can we pin-down the extent to which differences in techniques of planting are responsible for variations in the labour input for sowing? (3) What precisely determines the extent of labour input into weedin (4) To what extent do the Surveys capture the use of human, mechanic and animal power in post harvest operations? If these inputs are measured properly, would it make any difference to the overall intensity and pattern of labour use? (5) In each major operation, what is the degree of substitutability between different sources of energy and how respnsive are farmers to differences in their relative costs?

IV

Trends in human and animal labour use in Selected districts

80. Analysis of cross-sectional variations, whether across space or across size class of holdings is apt to be vitiated by the fact that we could not fully capture variations in soil conditions, natural rainfall and its seasonal distribution, and such other factors. This limitation, one may hope, would be less serious which we consider changes in productivity and input use in the same districts over time. Such an analysis is possible in respect of three districts (namely Ferozepur, Muzaffarnagar and Coimbatore) for which three year average data on the relevant aspects are available for the mid-fifties and the mid-to-late sixties.[27/] The data in published reports are unfortunately not as detailed as one would like and there are some questions of comparability. Nevertheless some broad trends based on estimates of district averages for the relevant variables is possible and this shows significant patterns.

81. As can be seen from table 20, all three districts have experienced significant increases in productivity (measured by the gross value of crop output per unit area). Deflating these by the change in the index of wholesale prices for food articles,[28/] the real increase in productivity ranges from 45% in Ferozepur to 130 % in Muzaffarnagar.

Table 20

Trends in crop production per hectare, selected districts

District	Unit	Period I	Period II	Indices (Period II / Period I x) Current prices 4/	Constant prices 5/
(1)	(2)	(3)	(4)	(5)	(6)
Muzaffarnagar 1/	per cultivated ha.	595	3288	570	224
	per cropped ha.	440	2400	545	214
Ferozepur 2/	Per cultivated ha.	402	1832	455	171
	per cropped ha.	383	1408	367	138
Coimbatore 3/	Per cultivated ha.	295	1889	640	221
	per cropped ha.	266	1322	500	172

1/ Economics of Farm Management, Muzaffarnagar, Combined Report, 1966-, pp.261, 262.

2/ Economics of Farm Management, Ferozepur, Combined Report, 1967-70, pp.56-57.

3/ Economics of Farm Management, Coimbatore, Combined Report, for 1970-73, p.75.

4/. Column 4/Column 3 x 100.

5/ Column 5: Index of all India wholesale prices (food articles) for Period II relative to Period I.

Note: Period I in all cases refers to 1954-55 to 1956-57.
Period II relates to 1966-68 for Muzaffarnagar, 1967-70 for Ferozpur, and 1970-73 for Coimbatore.

82. The increase in productivity per ha. of TCA is the combined result of a rise in cropping intensity, shift in crop patterns, and changes in yields of individual crops. In all three districts there has been a significant expansion of irrigation, as well as a change in the quality of inputs. In Ferozepur and Muzzaffarnagar, the qualitative shift is in the introduction of tube-wells; while in Coimbatore there has been a substantial increase in the share of Canal Irrigation. In all cases, the expansion and improvement of irrigation is accompanied by increased cropping intensity, the increase being most marked in Coimbatore, the crop pattern shifts are also most prominent in Coimbatore, while in Muzaffarnagar and Ferozepur the shift is largely from wheat mixtures and gram to pure wheat crop, and from local to high yielding varieties. In all districts, the increase in aggregate productivity per hectare has been accompanied by more intensive use of manures, fertilisers and plant protection materials. Overall, the rise in production per unit area in Coimbatore seems to be due primarily to higher cropping intensity, spread of irrigation and switch to higher value crops. In the other two districts the spread of irrigation and the sharp rise in yields of the major crops (partly the result of the introduction HYVs) were more important than changes in crop patterns(Table 21)

(Table 21)

83. The total human labour input per hectare for crop production has increased in Ferozepur and Coimbatore, but fallen in Muzaffarnagar. In all cases bullock labour per unit area has fallen sharply. In Muzaffarnagar the percentage reduction in animal labour input is less than in that of human labour. Moreover in all districts, the HLD and BLD use for individual crops for which data are available, have fallen; and the reduction in BLD is uniformly much greater than in HLD (Table 22).

Table 21

Factors Contributing to Increased Productivity in Selected Districts

	Muzzaffarnagar 1/		Ferozepur 2/		Coimbatore	
	Period I	Period II	Period I	Period II	Period I	Period II
Percentage Area Irrigated 1/	73	93	69	87	20.5	50.0
Cropping Intensity 2/	134	137	121	128	90	143
Yields/ha: Major Crops 3/						
Wheat - Desi	10.25	20.31	11.8	15.99	-	-
Wheat - HYV			-	25.40	-	-
Maize	9.76	13.78	na		11.3 8/	11.0
Paddy	14.40	22.28	na		23.2	29.9
Cotton Desi	-	-	5.98	8.28	6.3	13.1
Cotton American	-	-	6.43	11.45		
Sugar Cane	300.1	424.6		na	na	na
Ground nut	-	-		na	8.6	9.0
Share of Principal Crops 5/ in Total Cropped area						
Wheat			14.3	35.8	nil	
Wheat - mixtures			20.7	3.9	nil	
Gram	48.8 5/	52.5 5/	13.4	4.0	nil	
Other cereals			1.4 6/	4.3 6/	44.3 9/	26.3 9/
Paddy			3.1	3.4	5.6	11.4
Sugar cane	22.1	23.0	0.7	1.3	na	na
Cotton			4.3	6.4	12.8	5.9
Ground nut			2.2 7/	2.7 7/	8.8	19.5
Others	24.9	16.2	39.9	38.2	28.5	37.1

Notes:
1/ Muzaffarnagar, CR 1966-69, p.261, Ferozepur CR, 1967-69, p.26, Coimbatore CR, 1970-73, p.236.

2/ Muzaffarnagar, Ibid, p.261, Ferozepur, ibid, p.27; Coimbatore, Ibid, p.236.

3/ Muzaffarnagar, ibid. p.263, Ferozepur, ibid, pp.87, 100, 113, Coimbatore, ibid, 237.

4/ Muzaffarnagar, ibid, 261, Ferozepur, Ibid, p.30; Coimbatore, ibid, pp.26-32.

5/ relates to "Food Crops"; 6/ relates to maize; 7/ relates to oil s

8/ relates to Irrigated Jowar; 9/ relatives to Jowar, Bajra and Ragi.

Table 22

Trends in input of human and animal labour per gross cropped ha.

	Period		Wheat	Paddy	Other food-grains 1	Other food-grains 2	Sugar-cane	Cotton 1	Cotton 2	Ground nuts	All crops
Muzaffar-nagar	I	HLD	78	89	105	32	198	-		-	181
		HLD	41	20	12	14	39			-	39
	II	HLD	69	70	47.5	38.2	132	-		-	121
		BLD	27	12	9.5	16.5	31	-		-	29
Ferozepur	I	HLD	68.9	-	-	-	n.a	87.1	96.0	-	48.4
		BLD	62.8	-	-	-	n.a	40.6	35.4	-	60.0
	II	HLD	52.2	-	68.2		n.a	68.8	81.4	-	36.3
		BLD	15.6	-	14.6		n.a	13.7	12.0	-	13.5
Coimbatore	I	HLD	-	269	263		n.a		189	87	83
		BLD	-	138	96		n.a		57	15	26
	II	HLD	-	173	153		n.a		185	76	93
		BLD	-	23	14		n.a		9.2	6.5	9

Sources: 1/ Muzaffarnagar, CR, 1966-69, pp.260-264.
Other foodgrains, 1 refers to Maize and 2 to Grams.
Figures for sugarcane relate to planted crop. The labour use for Rattoon crop has also declined.

2/ Ferozepur, CR 1967-70, pp.71, 93, 95, 106, 107, 119, 120, 131, and 133. Cotton 1 refers to American cotton and 3 to Desi cotton.

3/ Coimbatore, CR 1970-73, pp.236-237.

84. Data on operation-wise use of the two sources of power is available only for a few crops in Ferozepur (Table 23). This suggests that the use of human and animal labour has fallen in practically all operations though unevenly. Thus in the case of Desi wheat, out of the 16 days reduction in total human labour input per hectare, 3 were in preparatory-tillage, 3 in interculture and 7.6 i[n] threshing; for American cotton, the total HLD/ha has fallen by 18 m[an] days, 6 of which was in land preparation, and 8 in interculture; an[d] for American cotton almost all the reduction (14 man-days) is under inter-culture and cutting of sticks.

Table 23

Data on operation-wise use of human and animal labour available for a few crops in Ferozepur

	Wheat Desi				American Cotton				Desi Cotton		
	HLD		BLD		HLD		BLD		HLD		BL[D]
	1	2	1	2	1	2	1	2	1	2	1
Tillage	16.9	13.6	30.1	10.6	14.0	8.2	25.8	7.6	11.2	12.9	21.5
Sowing	4.5	3.1	6.7	2.0	3.8	1.7	5.0	1.4	4.0	2.9	5.0
Manuring	1.5	0.7	1.7	0.1	3.3	0.7	3.3	0.3	1.9	0.5	1.7
Interculture	6.2	3.1	-	0.2	17.1	8.8	6.1	2.7	21.7	12.9	4.1
Irrigation	8.6	7.1	6.5	-	8.7	7.3	0.2	0.02	9.8	8.5	3.8
Harvesting	13.1	12.6	n.a	n.a	35.3 1/	34.1 1/	-	-	39.0	40.4	-
Threshing	18.1	10.5	17.7	1.9	4.9 2/	6.4 2/	0.3 2/	0.1 2/	8.0 2/	3.0 2/	0.2
Others	0.3	1.6	0.1	0.7	-	1.4	-	0.3	0.4	0.9	0.2
	68.9	52.3	62.8	15.5	87.1	68.6	40.6	12.4	96.0	82.0	36.4

1/ Picking 2/ cutting of sticks

Source: Ferozepur CR 1967-70, op.cit, pp.107,108,119,120,131 and 133

85. Again the reduction in bullock labour is much sharper than in human labour. The use of bullocks for Desi wheat has fallen by 47 pair days, per hectare mostly under land preparation (19.5 pair days), threshing (16 pair days) and sowing (4.7 pair days). In the case of Cotton, the reduction has occured primarily in land preparation and to a lesser extent in sowing, manuring and inter-culture.[29/]

86. The reduction in bullock labour use for land preparation is probably the direct consequence of tractorisation. While there were hardly any tractors in 1954-57, there was one tractor for every five holdings in the mid-sixties; similarly, the reduction of human labour use in threshing could be attributed to the introduction of mechanical threshing of which there were one for every 4 farms in 1966-69 compared to none in the mid-fifties.[30/] The phenomenal expansion of mechanical power for irrigation probably explains the reduction of human and, even more, in the animal labour used for irrigation. But the reasons for the sharp reduction in the use of human labour for manuring and inter-culture in all the crops are not clear: It could be due to the more widespread use of machines in these operations; to the use of more extensive use of fertilisers, which involve handling smaller volume of material per unit of nutrient; and perhaps to a tendency to substitute chemical for manual methods of weed control. These questions can be answered satisfactorily only on the basis of more detailed data than is currently available.

87. But one thing seems clear: the reduction in the use of animals is much more pronounced than in human labour in the Punjab. Since this occured in conjunction with the spread of mechanisation, it is perhaps reasonable to infer that the impact of mechanisation on use of animals is more pronounced than on human labour. Much the same is true of Coimbatore, which has also experienced a phenomenal expansion in the use of energised pumpsets and a significant growth in the use of tractors, though not of mechanical threshing. It is possible that the expansion of energised pumps significantly reduce the demand for both animal and human labour for irrigation, but we need operation-wise data before this can be verified. In both these cases, it is interesting that although the human labour use for individual crops has fallen, the overall labour use per hectare of all crops has risen probably because of the increase in the proportion of irrigated area and the shift in cropping pattern in favour of more labour intensive crops.

88. Muzaffarnagar presents an altogether different picture in that despite the substantial increase in irrigation, and in per hectare yield of most crops, the use of both human and animal labour per unit area has declined. As in the case of the other two districts the latter can perhaps be explained by the expansion of tubewells energised pumpsets and tractors. But it is not obvious why human labour use should also decline not only for individual crops but in the aggregate as well; there is certainly no indication that either the character or the intensity of mechanisation in the State has been fundamentally different from that observed in the other two districts

One possibility is that while the 1954-57 data relate to farms in Meerut and Muzaffarnagar districts, the data for 1966-69 relate only to a sample of Muzzafarnagar farms. If the crop patterns extent and quality of irrigation, and techniques of cultivation were markedly different in the two districts to begin with, the above comparisons may give a distorted and misleading picture.[31]

89. It is noteworthy that in all the three districts, the cost of human labour relative to bullock labour has declined, and that the ratio of human to animal labour input has increased. (Table 24). This would seem to support our hypothesis that the relative cost of different sources of energy is an important factor in determining the relative proportions in which they are used.

Table 24

Changes in ratio of human to animal labour and their relative costs

	HLD/BLD			Cost of HLD/BLD*		
	Period I	Period II	Index	Period I	Period II	Index
Muzaffarnagar	3.1	3.8	123	0.28	0.18	64
Ferozepur	1.4	4.4	314	1.30	0.89	68
Coimbatore	3.2	10.3	322	0.32	0.29	91

* These ratios are computed from Table 26.

90. While this may reflect, to some degree, a tendency to substitute human for bullock labour in response to the relative cheapening of the former, it would be erroneous to conclude that this is the whole or even the primary explanation. Since our cross-section data do not show either strong or a universal substitution relation between the two sources of power, and since technologically

bullock labour may be more of substitute for machine labour per effective unit of work done before one can interpret the true significance of the sharp increase in the human to animal power tatio and its underlying causal factors. Such an exercise must await access to more detailed data than is available in published reports.

91. Assuming that the average use of human labour for the sample farms is representative of the districts, we can compare the changes in total employment in crop production with the increase in the rural population, the latter being taken as a rough index of the increase in the supply of labour for agriculture.[32] Assuming that the rural population has risen at the rate of 1.5 per cent a year, the total rural work force between the successive FMS under study has risen about 20 per cent in Ferozepur and Muzaffarnagar and 25 per cent in Coimbatore. It would, therefore, seem that except in Muzaffarnagar, the increase in aggregate human labour use for crop production alone has been considerably more than the increase in the number of workers dependent on agriculture. (In the case of Muzaffarnagar, for reasons cited in para , the doubts abou comparability of the data warrant caution in drawing conclusions) This would suggest either that the average intensity of employment per worker (measured by the number of man-days per worker per annum) has risen, or that there has been considerable immigration of labour into Ferozepur and Coimbatore. We cannot verify the relative import of the two; nor do we know whether any increased migration is of a temporary (seasonal) nature or is of a permanent character.

92. There is some indication that the intensity of family labour participation in cultivation may have declined both in terms of the labour force participation rates[33] in cultivating households and of the average number of days per annum for which the farm family worker is employed. In Ferozepur, a farm family worker was employed for 298 days in a year during 1964-70, compared to 324 days in 1954-57,[34] and the number of earners per farm has declined (2.19 to 2.17) despite an increase in average family size (7.7 to 8.5).[35] Coimbatore also seems to have experienced similar trends: The average family size has risen marginally (from 5.23 to 5.30) the proportion of earners has dropped (from 58 per cent to 49.4 per cent)[36] and the number of days worked in a year by a adult male family farm worker has fallen (from 265 days to 246 days).[37] Muzaffarnagar shows a very different picture in that the labour force participation rate in farm families has risen sharply (from 31% to 49%),[38] while the average annual employment per adult male has fallen (from 287 to 190 days).[39]

93. In general the proportion of hired labour to total labour use in crop production has increased sharply in all the three district. from 27.5% to 40.2% in Muzzaffarnagar; from 30 per cent to 49 per cent in Ferozpur, and from 21.7 per cent to 85 per cent in Coimbatore. The distribution of hired labour as between permanent and casual workers is available only for the latest surveys in the case of Ferozepur and Coimbatore. But in both cases, the average number of days of employment for permanent farm servants show a decline (Table 25).

It is however, not possible to judge from the published data whether the increase in dependence on hired labour has been accompanied by any shift in the relative roles of permanent and casual labour.

Table 25

Proportion of Hired to Total Human Labour for all Crops

	Period I		Period II	
	% Hired labour	Average animal employment AFS	% Hired Labour	Average ani Employment
Muzaffarnagar	27.5 1/	n.a	40.2 2/	275 3/
Ferozepur	29.2 4/	412	48.8 4/	323 5/
Coimbatore	26.2 6/	365 7/	84.9 6/	256 7/

Note: 1/ Muzaffarnagar CR, 1954-57, p.47, Relates to total farm business.
2/ CR 1966-69, p.73, Relates only to crops.
3/ ibid, p.42
4/ Ferozepur CR, 1967-70, pp.71
5/ ibid., p.45
6/ Coimbatore CP, 1970-73, and 236
7/ ibid., p.45 relates to adult males only.

94. The phenomenal rise in the hired labour is associated with a general tendency in all districts for increase in the size of operational holdings. The average size of holding, as well as the area operated per holding has increased sharply between 30 and 40 percent in all districts.[12] That this has taken place during a period where the average cultivated area per capita must have declined, permits only of one inference, namely, that the small

farmers and tenants have increasingly been dispossessed of their holdings and have swelled the ranks of the agricultural labour classes dependent primarily on wage employment. The Ferozepur and Coimbatore data suggest that this process has occurred through a sharp reduction in land cultivated under tenancy arrangements. The ratio of leased-in to operated area in the former district has fallen from nearly 38 per cent in 1954-57 to 11 per cent in 1967-70, almost the entire reduction being under the category of share tenancy[41/]. In Coimbatore, the percentage of land area leased out has fallen from 20.5 per cent to 3.8 per cent and that leased-in from 10.3 to 5.3 per cent thus showing a reduction in net area leased out.[42/] All this clearly suggests that apart from changes in the distribution of land ownership, (about which we don't have enough data) resumption of land previously cultivated by tenants for personal cultivation by owners has been a major source of increase in the average size of operational holdings.

95. It is also apparent that in all three districts the average farm business income from crop production of families per man day of work contributed by their members has risen much faster than average daily wage rate per man day of hired labour: The difference is most striking in Muzaffarnagar where the former has risen nearly 10 times as much as the latter; in Ferozepur and Coimbatore the total income per man day of work for farm family workers has risen 2 to 2½ times as much as that of the average daily wage rate for hired labour. (Table 26).

Table 26

Trends in Employment, and Average Income per Man-day of Family and Hired Workers

		Number of Mandays/farm		Income		Income/ Manday		Index II/I
		I	II	I	II	I	II	
Muzaffar-nagar	A	480[1]	336[2]	1143[3]	16457[4]	2.38	42.6	17.90
	B	13.8[5]	29.5[6]	18[7]	71[8]	1.3	2.4	1.85
	C					4.7[25]	13.6[26]	2.89
Ferozepur	A	342[9]	439[10]	1359[11]	8190[12]	3.97	16.75	4.22
	B	5.5[13]	38.4[14]	16.8[15]	207[16]	3.05	5.39	1.77
	C					1.8[27]	6.05[28]	3.36
Coimbatore	A	246[17]	178[18]	519[19]	4806[20]	2.11	27.0	12.8
	B	15.0[21]	79.3[22]	13.8[23]	227.5[24]	0.92	2.87	3.12
	C					2.84[29]	9.83[30]	3.46

A: Farm Family Employment and Farm Business Income
B: Hired Human labour and cost of hired labour
C: Net maintenance cost per working day per pair

1/ p.76, F.425, relate to crop production CR, 54-57
2/ p.73, CR, 66-69
3/ p.76, Table 4.25, CR, 54-57 (crop)
4/ p.262, relate to crops only
5/ Total labour/acre for farm operations (p.51) x .275 (share of hire labour) p.47, CR. 54-57
6/ p.74, CR, 66-69
7/ Rs.54/acre (p.70) x .33 (p.71) CR, 54-57
8/ p.64, CR, 66-69 ; 9/ FL/GC acre (p.65) x GCA/farm (pp.8.17) CR.
10/ FL/GCA (p.71) x GCA/farm (pp.22,30), CR, 67-70
11/ p.62, CR, 1954-57 (Crops only) ; 12/ p.66, CR, 1967-70/farm (crops
13/ p.65, CR, 1954-57/GC acre. ; 14/ p.70, CR, 1967-70/TCA.
15/ Value of Hired Labour/GC acre (p.55 CR, 1954-57) x CI (129)
16/ p.66, CR, 1967-70/TCA ; 17/ FL/na GCA (60.93) x AV GCA/farm (4.24) pp.223, 81. 18/ CR, p.62 relate to whole families
19/ p.81 (whole farm) relates to 1955-57

Contd......

96. It seems likely that the significant rise in the ratio of hired to total labour input is indicative of growing proletarianisation of agricultural labour force at least in these three districts. This must have had a depressing effect on the bargaining power and, hence, the wage rates, of hired labour. One cannot however, draw any definitive conclusions from these comparisons regarding the trend in overall income distribution. We would need to know more about the changes in (a) the relative proportions of workers dependent on wage labour to workers on family farm, (b) the dependency ratios in the two classes; and (c) the output, employment and their distribution as between these two major classes of rural population.

Contn.

20/ p.31, Report for 1970-73, relate to whole farm 1971-1972.

21/ Sum of hired labour/Number of days .... for 1954-55 (7.2 days p.63 of the 1954-55 report) and 1955-56 (7.2 days, p.57 of the 1955/56 report).

22/ p.63/ha. GCA for crop alone

23/ wage of hired labour/acre total for 1954-55 and 1955-56

24/ p.59 hired labour/ha GCA for crop alone

25/ p.59, CR 54-57

26/ p.48, CR 66-67

27/ & 28/ p.51, CR 67-70

29/ & 30/ p.236, CR 70-73.

NOTES

* Research on this subject is part of ongoing research at the Centre for Development Studies. An earlier paper (see 5/ below) dealt with inter-country variations. The present paper presents some preliminary results of a study of variations in labour use within India at the specific request of the Asian Regional Programme for Employment Promotion of the International Labour Organization for a Seminar to be held at Bangkok in August 1978.

** I am grateful to M.Krishnaji for his critical comments and several valuable suggestions on the first draft of the paper and to A.V. Jose for sharing in the tedious task of collecting and copying a mass of data. I am specially indebted to Purushothaman Nair who, with Sujana Bai's assistance, gave generous help in statistical analysis of data. None of them, of course, are responsible for errors in analysis or interpretation.

1/ See Krishna Bharadwaj: Production Conditions in Indian Agriculture, (Cambridge, 1974).

2/ The literature on this subject has been thoroughly, and critically reviewed by Kalpana Bardhan "Rural Employment, Wages and Labour Markets in India: A Survey of Research", EPW, Review of Agriculture, June 1977; July 2, 1977; and July 9, 1977.

3/ In sheer volume the literature on these aspects is formidable: Kalpana Bardhan, op.cit, gives a bibliography which covers most of the important contributions. Part II of her article discusses some of these studies. The literature on effects of tractorisation on various aspects of agricultural production (including employment) has been comprehensively surveyed by Hans Binswanger, The Economics of Tractors in the Indian Subcontinent: An Analytical Review, ICRISAT(mimeo, unpublished), Hyderabad, 1977. Special mention should also be made of Shakuntala Mehra's study entitled Some Aspects of Labour Use in Indian Agriculture, Occasional Paper No.88, Department of Agricultural Economics, Cornell University (mimeo, June 1976). This is one of the most systematic efforts to analyse changes in employment consequent on the extension of irrigation and shifts in crop pattern.

4/ Shigeru Ishikawa, Economic Development in the Asian Perspective, Kinokuniya, Tokyo, 1967).

5/ See A. Vaidyanathan and A.V. Jose: Absorption of Human Labour in Agriculture - A Comparative Study of Some Asian Countries, CDS Working Paper No.56 (Mimeo, October 1977).

6/ Almost all Farm Management Survey Reports fit Cobb-Douglas type production functions to the input output data for all crops, as well as selected individual crops, and estimates marginal productivities of selected inputs. The conventional production function approach has also been used by numerous authors, to test the efficiency of resource allocation (See 9/ below), to explain sources of growth in agricultural output verify whether Indian agriculture is characterised by constant, increasing or decreasing returns to scale, and measure the contribution of technical progress to growth of output.

7/ See for instance, Ralph Parsons Company, Joint Indo-American Team Report on Efficient Water Use and Farm Management Study: India, prepared for Government of India and United States Agency for International Development (mimeo, January 1970). B.S.Minhas, K.S. Parikh and T.N.Srinivasan: "Towards the Structure of a Production Function for Wheat Yields with Dated Inputs of Irrigation Water," Water Resources Research, vol.10, No.3, June 1974.

8/ David W. Hopper's paper entitled: Alternative Efficiency in Traditional Indian Agriculture (IADP Staff Working Paper, Ford Foundation, 1961) was one of the earliest attempts to establish that the Indian farmer allocates his resources in a manner which ensures marginal products of inputs (estimated by fitting Cobb-Doublas production functions to data for farms in one village) are roughly equal to their market prices. This approach has been severely criticised by among others, Krishna Bharadwaj, op.cit., Ashok Rudra, "Allocation Efficiency of Indian Farmers: Some Methodological Doubts", EPW, January 6, 1973.

9/ For a critical review of some of these studies, see Kalpana Bardhan, op.cit. part III, EPW, July, 1977.

10/ See Binswanger, op.cit. The limitations of these studies are brought out clearly by this paper.

11/ Some of these points are argued at some length in A.Vaidyanathan, "Performance and Prospects of Crop Production in India", EPW, Special Number, August 1977, and

A. Vaidyanathan, "HYV and Fertilisers: Synergy or Substitution: A Comment", EPW, June 24, 1978. The latter was a comment on an earlier article by K.S. Parikh published in the same Journal (March 1978).

12/ Binswanger, op.cit.

13/ Details regarding the sources of data, the manipulations made for purposes of the present analysis and their limitations are spelt out in the Annexure I. The relevant data for different size classes of holdings in each the selected districts in respect in respect of total crop production are given in Annexure II, and for paddy in Annexure III.

14/ As a rule we have taken the total rainfall and the proportion occuring in June-September during the survey period from the FMS reports. But in some cases, since the data were not readily available we have used "normal rainfall". It should also be noted that the index of seasonal distribution does not always relate to June-September; in some districts the data are reported for May-August.

15/ We did not include x_2 and x_3 among explanatory variables in the regressions for 11 districts because the number of such variables would then become too large relative to the sample size.

16/ We also tested the relation between cropping intensity (Y) an on the one hand and rainfall (x_1), its seasonal distribution (x_2), irrigation (x_3) and the quality of irrigation (x_4).

The estimated regression is:

$$Y = \underset{(7.70)}{92.25} + \underset{(1.68)}{0.01x_1} - \underset{(-1.07)}{0.093x_2} + \underset{(5.68)}{0.56x_3^{**}} + \underset{(0.132)}{1.85x_4} \qquad R^2 = 0.73$$

Dropping x_4 whose coefficient is insignificant we get

$$Y = \underset{(9.53)}{93.09} + \underset{(1.84)}{0.009x_1^{*}} - \underset{(-1.13)}{0.069x_2} + \underset{(5.98)}{0.56x_3^{**}} \qquad R^2 = 0.73$$

It seems that total rainfall, and the proportion of area under irrigation have a strong effect in increasing cropping intensity. A high seasonal concentration of rainfall tends to depress it, but the effect is not significant.

17/ The last two factors could be incorporated once we get access to detailed farmwise data for the survey districts, which has the added advantage of vastly enlarging the sample size.

18/ This is necessary because we could not re-estimate output at uniform prices beyond the district level. Note, however, that unlike in the district cross-section where output of each crop in all districts have been evaluated at a uniform (all-India average) price, the output values in the intra-district analysis are based on prices prevailing in the respective districts, at the time of Survey. The latter has the advantage of reflecting price differentials due to quality differences; but they may also reflect market imperfections. It should also be noted that manures and fertilisers in the intra-district cross-section analysis are all in value terms; the quantity data are not available in the published reports.

19/ See Annexure I for details of estimations.

20/ I am grateful to Krishnaji for pointing this out.

21/ In an unpublished paper entitled India's Energy Consumption: A Statistical Appraisal (mimeo, 1977) Ashok V. Desai has attempted to quantify the effective work output of human and animal labour, on the basis of their food intake. He estimates that, on the average, a bullock has four-to-five times as much work capacity as a human per day of work. The total human and animal energy input in agriculture (estimated from FMS data, on number of days of work and Desai's conversion factors), however, does not seem to bear any significant relation to productivity, perhaps because it does not allow for the inter-regional and inter-farm variations in the work capacities of humans and animals. This point needs more careful checking.

22/ In an unpublished paper (1971) the author found, on the basis of an analysis of State-wise data for the early sixties, that the proportion of wage labour households is negatively associated with average area operated per household (correlation -0.37*) and positively with the same degree of inequality in land distribution (+0.77**). Together they account for 80 per-cent of the variation in the proportion of wage labour to total rural households across States.

23/ See Kalpana Bardhan, op.cit. Part II.

24/ Since we are using value of manures and fertilisers as an index of plant nutrients, there is also an implicit assumption that the cost per unit nutrient from either source is the same, for all classes of farmers. This assumption needs to be verified.

25/ The Farm Management Surveys were replaced by Cost of Cultivation Studies from 1973. These studies, being meant to help the determination of agricultural price policy, follow a different design. In general, the samples are drawn to provide representative picture of costs, etc. for a particular crop by States. However, the schedules also collect detailed data on all aspects of the farm economy of the selected sample households.

26/ See ICAR, Institute of Agricultural Research Statistics, Sample Survey for Assessment of High Yielding Varieties Programme, Annual Reports, (New Delhi). These Reports are published in a mimeographed form for 1970-71 to 1974-75.

27/ Ahmednagar and Hooghly have also been surveyed in the late 'sixties but the reports were not available to us at the time of writing.

28/ This is admittedly a crude procedure. A more appropriate index should take into account the price indices for different crops pertaining to each district and the differences in their relative importance in total output.

29/ The reduction in bullock labour input is, however, inconsistent with the fact that the number of draught animals per hectare has fallen only 24 per cent (from 0.31 per ha. to 0.23 per ha), and the average rate of utilisation shows but a marginal reduction (from 163 days to 158 days per annum). This suggests that the 1954-57 data for bullock use may be in animal days or pair days. The suspicion is corroborated by the following further fact: Since as a rule one man works with a pair of bullocks in land preparation, the ratio of HLD to Bullock pair days should be close to unity. While this is so in 1966-69, it is only half in 1954-57. Even if the 1954-57 figures were in animal days, and were converted to pair days, the bullock labour input still shows a sharp reduction and the reduction will be more consistent with the trend in number of animal/ha, and their utilisation.

30/ There were 33 tractors and 42 mechanical threshers in the Ferozepur sample in 1960-70, which consisted of 150 farms. See Ferozepur CR, 1967-70, p.

31/ The Combined Report for 1954-57 shows that the average size of holding in Muzaffarnagar was higher than in Meerut; the proportion of cultivated land held under Bhumidari tenure (which convers full proprietorship) was also higher in the former. Data on differences in other aspects are not available in the Report.

32/ Strictly speaking, of course, we should use the number of adult equivalent units of workers reported to be dependent on agriculture. The latter can differ from the rate of population growth due to changes in the age composition and in the participation rate. There is some evidence of a decline in overall, and age specific, participation rates especially for females. Since comparable data on this are not available at the district level, we take total population growth as a rough proxy for the growth of rural work force.

33/ The evidence is reviewed at some length by Kalpana Bardhan, op.cit. Part I.

34/ Ferozepur CR, 1967-70, op.cit. p.44.

35/ Ibid, pp.42, 43.

36/ Coimbatore CR, 1970-73, op.cit. p.39.

37/ Ibid, p.236.

38/ Muzaffarnagar CR, 1966-69, op.cit. p.260.

39/ Muzaffarnagar CR, 1966-69, ibid, p.39; and Meerut/Muzaffarnagar CR, 1954-57, op.cit. p.53.

40/ It has risen from 4.2 ha. to 6.5 ha. in Muzaffarnagar (CR, 1966-69, p.260); 9.3 ha. to 12.4 ha. in Ferozepur (CR, 1967-70, p.24); and 5.99 ha. to 5.77 ha. in Coimbatore (CR, 1970-73, p.23

41/ Ferozepur, CR, 1967-70, p.26.

42/ Coimbatore, CR, 1970-73, p.20.

Annexure I

A Note on Sources and Limitations of Data

A.1. The basic data used in this paper are almost exclusively drawn from published reports of Farm Management Surveys (FMS). These surveys collected detailed data on holding size, land use, tenancy, crop pattern, yields, and the quantum and value of major inputs by crops and operations for a scientifically chosen sample of cultivators using uniform concepts and methodology. Altogether 31 districts have been covered, and five of them have been surveyed twice.

A.2. These are Amritsar, Ferozepur, Salem, Coimbatore, Meerut, Muzaffarnagar, Hooghly, 24 Parganas, Ahmednagar and Nasik (1954-57), Akola, Amroati (1955-57), West Godavari, Sambalpur, Monghyr (1957-60), Shahabad, Bangalore (1960-63), Karnal-Rohtak (1961-64), Alleppey-Quilon, Mandya, Raipur, Pali (1962-65), Deoria, Muzaffarnagar, Surat-Bulsar (1966-69), Thanjavur, Cudappah, Cuttack, Ferozepur (1967-70), Ahmednagar, Nowgong (1968-71), Hooghly (1969-71) and Coimbatore (1970-73). As a rule for each district reports are prepared for individual years and for the 2 or 3 year period as a whole. Though most of these reports have been published (either in a mimeographed or printed form), all of the reports were not readily available to us at the time of when research for this paper was being done. We have also had to omit one or two districts because of apparent inconsistencies in the published data which could not be cleared up.[1/] Since 1973, the FMS have been discontinued having been replaced by the Cost of Cultivation Studies.

A.3. Though the districts themselves were not selected with any specific criteria in mind, they do capture a wide range of agro-climatic conditions prevailing in India. The data were collected by the Cost Accounting method[2/] which is based on a detailed record of the activities of each sample farm involving periodic visits by field investigators subject to intensive supervision. The published reports generally present tabulations by five (and, in some earlier years, eight) size classes of holdings, and occasionally by sub-regions, in a more or less standardised format for individual years as well as in a consolidated form for three years. We have as a rule used the three year averages, which has the advantage of reducing abberations in outputs and in input use caused by random variables (especially weather).[3/]

A.4. While these are considerable advantages, reliance only on published reports does involve some limitations as well. In the first place, not all reports are equally detailed; and it is not uncommon to find differences in the manner of presentation of data. Secondly, all the reports do not give all the relevant information. Thus details of the quantum of manures and fertilisers used are available only for the sample farms as a whole, and rarely by size class of holdings, and that too for 11 out of 18 districts covered by the present study; operationwise breakup of human and bullock labour for total crop production is published in only 2 or 3 reports, and even in the case of individual crops such details are missing in several districts. Thirdly, the basis for conversion of human labour into standardised man days is not always clearly indicated. Fourth, since the surveys for different districts were conducted at different points of time, the value figures are not directly comparable. It was necessary to re-work the value of crop production at constant prices for all districts to achieve comparability. Fifth, data on the quantum of machine labour and its costs are not available in most cases; even in more recent reports the information is quite sketchy. And sixth, as the published tabulations give a break-up only for the limited number of size classes of farm holdings, the number of observations is far too small to permit meaningful statistical analysis of intra-district variations. We have tried to overcome this by grouping districts according to the year in which the Surveys were conducted, and by using estimates for size classes and sub-regions in particular districts.[4/]

A.5. In order to overcome these limitations and ensure a reasonable degree of comparability in the data we have had to make several adjustments and manipulations. These are spelt out in some detail below. It should be emphasised that the adjustments one by no means complete or satisfactory. There is considerable room for refinement which will be possible if we can get access to the primary data for the Sample farms. Efforts are being made to secure this data.

Estimation of gross output per hectare

A.6 Since the surveys in different districts were conducted at different times, and since neither absolute nor relative prices have remained constant, the money values for inputs and outputs as given in the Reports are not comparable. In so far as our analysis uses physical quantities (as it does in the case of yields of individual crops, and inputs of human and animal labour, and in many instances, manures and fertilisers), this is no difficulty. But problems arise when data are not available in physical terms (this is the case for manures and fertilisers in some districts and for all size-classwise analysis especially for the total crop of sample farms), or where a uniform basis for valuation in money terms is essential to express physical quantities in comparable units (as is the case with total crop output).

A.7. In this study, we have re-estimated the value of crop output for all survey districts at the average prices of 1970-71 to 1972-73. For this purpose, the all India average unit prices of different crops were computed from the CSO estimates of output value of each crop during these above three years[5/] and the corresponding figures of physical output as reported by the Ministry of Agriculture.[6/] Crops for which physical production of data were available have been evaluated at these prices. Since, as a rule, physical production data are not available for all crops, the total value of crop output has been estimated as follows: The Reports for each district give the total output value of all crops(including those for which physical output data are not available) and the value of crops for which physical output data published. The ratio of the former to the latter is applied to the aggregate value(at 1970-72 prices) of crops for which physical production figures are published. This procedure suffers from the following limitations: First, it does not allow for variations in farm harvest prices associated with qualit differences of the same crop within and between districts. Second, the recomputed estimates do not include the value of by-products. This would not be a problem if the ratio of by-product to main product were uniform across crops and regions. Unfortunately it is not so.[7/] Third, the procedure for adjusting the estimates for crops for which physical output data are not available implicitly assumes that the ave rage prices of the latter have moved in the same proportion as those for which production and price data are available. While there is clearly room for refinement of our estimates of the value of total crop output at constant prices, it is believed that they capture major differences in the relative productivity of crop production per hectare across the sample of districts considered for analysis.

Irrigation

A.8. As a rule, the published reports give data on the proportion of cultivated and cropped areas under irrigation, as well as a break-up of net irrigated area by sources. However, in some cases only the proportion of irrigated to total cropped area of to cultivated (or net sown) area is given. We have used whatever is published in such cases. Since the proportion of cropped area irrigated is not always equal to that of cultivated area irrigated, the figures are not strictly comparable across districts. This limitation may be compounded to the extent that the concepts and definitions of irrigated area are themselves not standardised.

Manures and Fertilisers

A.9. In each district data on quantum and value of per hectare input of farm yard manure (FYM) is available for major crops. From this we computed average unit value per kg. of FYM - the average being a simple average of unit value for crops in respect of which data are published. For each district, this unit value was then applied to the value of FYM input per hectare of total cropped area to get at quantum. The same procedure was also used for estimating fertilisers in terms of nutrient equivalents. (There are however a few cases where with the nutrient equivalents are either not available or fertilisers are merged in FYM (Hooghly, 24 Parganas). There is no way of adjusting for them. In the case of Deoria, we have in effect assumed that cost per unit nutrient from fertilisers is the same as that from FYM.

A.10. An alternative procedure is to calculate the weighted average per hectare application of FYM and fertilisers for the crops for which detailed input data are available and assume that this average applies to the rest of the crop as well. The implicit assumption here is that the crops for which detailed data are given are representative of the total. This may not be correct because irrigated, high valued, commercial crops, which tend to be more intensively fertilised, are usually part of the residual. While the two estimates naturally differ the relative position of districts in terms of fertilisers and manure use is more or less the same in both estimates.

A.11. We have used the first estimate in this analysis. It has been assumed that on the average, the plant nutrient content of FYM is 1.5 per cent. This figure, derived from the data for Muzaffarnagar[8/] is open to question. Other sources, however, suggest a much lower figure.[9/] Also, the assumption that the nutrient content of FYM is the same in all sample districts may be questioned. For these reasons, the estimated intensity of fertilisation (in terms of total plant nutrient) should be treated as only approximations capable of considerable refinement.

Estimation of Human and Animal Labour input

A.12. As a rule, the reports give estimates of the input of human (and animal) labour for crop production in the aggregate and for a few major crops, major operations and size of holdings in terms of number of standardised mandays (or pair days) per hectare. The standardised "manday" is normally defined as 8 hours of work by an adult male. Work done by adult females and children are converted into standard days on the basis of specified conversion factors. However, the conversion factors, and their rationale, are not always stated explicitly. Some reports indicate that the conversion factors are based on the ratio of daily wage of female and children respectively to that of adult males. A few [10/] do not even state clearly whether or not the figures of human labour input are in standard days.

A.13. While most reports give estimates of total human (and animal) labour input per hectare of total cropped area, same of the earlier reports[11] are not clear whether the base is cultivated or cropped area. In such cases, the figures have been checked (usually with the help of estimates of output or input per farm and per hectare) and appropriate corrections made to get at averages per unit of cropped area. Where possible similar adjustments have also been made for getting inputs and output per unit of cropped area in different size classes of holdings.

A.14. There is some ambiguity about the scope of labour utilisation accounted under the category of crop production, especially regarding the treatment of time spent on transporting produce to markets, and in processing of produce in the household. To this extent, the estimate of human labour use in crop production used in this study are incomplete.

Labour use for Animal Maintenance

A.15. All FMS reports used in this study give estimates of direct human and animal labour input for crop production per unit area. However, with a couple of exceptions, they do not give estimates of human labour use for maintenance of livestock. The labour used for maintenance of animals has been estimated by us on the basis of (a) the average number of man days spent on maintenance per draught and per milch animal separately, and (b) the number of draught and milch animals per hectare of cropped area. In most cases (a) had to be estimated by dividing the average annual upkeep labour changes per animal with the average daily wage per man day. Labour use in maintenance of young and other livestock cannot be estimated from the FMS data.

Cost per human and animal labour day

A.16. These have been uniformly estimated by dividing the total money cost of each input per unit area with the corresponding physical quantity of human and animal labour time (expressed in standard days). It may be noted that most reportes give separate estimates of the net maintenance cost per day of owned bullock labour. But these are often at substantial variance from the estimates derived from money value of animal labour and its physical quantum. We have preferred to use the latter.

Other adjustments

17. Several reports (especially those for the earlier years of the FMS) do not give data on inputs and outputs per unit of gross cropped area. We have used estimates of cropping intensity to convert all estimates on a per-gross-cropped-hectare basis. While the reports generally follow a standard definition of cropping intensity (GCA/Total Cultivated Area), a few are rather ambiguous on this point. The estimation of relevant magnitudes by landholding classes also presented some problems as the size classes used for inputs and outputs do not always coincide. While we have tried to cross-check the figures carefully, some errors (of ommission and commission) cannot be ruled out.

Mechanical Power

A.18. In the absence of relevant data from FMS, we have taken the number of diesel engines, pumpsets and tractors as reported in the quinquennial Livestock Census closest to the years in which the FMS was conducted in each district. The total horse power equivalent of these equipments (estimatedon the assumption that a diesel engine/pumpset has 5 HP, and a tractor 25 HP) was divided by the total cropped area of the District in that year. The district average HP/hectare is assumedto be a reliable approximation of the relative stock of mechanical power in the sample farms also. This is admittedly a crude procedure on several counts and there is scope for considerable refinement by taking into account (a) the actual stock of different kinds of machines in the sample farms; (b) including mechanical appliances other than tractors and pumpsets (e.g., sugarcane and oil crushers) and (c) variations in the HP ratings of appliances and their utilisation rates across regions and farms.

Notes to Annexure I

1. The following is a list of the Report used in this study. These reports are published by GOI, Ministry of Food and Agriculture, Directorate of Economics and Statistics, under the general title of Studies in the Economics of Farm Management: The references in particular reports are given below:

1. P.N.Driver	:	Bombay, Combined Report: 1954-55 to 1956-57 (Delhi, 195) covers Ahmednagar and Nasik districts.
2.	:	Rajasthan. Combined Report: 1960-1963 (covers Pali district.
3. J.M. Advarya	:	Surat, Bulsar (Gujarat) Combined Report, 1966-67 to 1968-69 (Delhi, 1976).
4. S.N.Gupta & P.K.Hazra	:	Punjab, Combined Report 1954-55 to 195 ( ) covers Amritsar and Ferozepur districts.
5. S.N.Gupta and P.K.Hazra	:	Sambalpur District (Orissa) Combined Report: 1957-58 to 1959-60 (mimeo, 1968) covers Sambalpur district.
6. D.L.Narayana	:	Cuddappah District (Andhra Pradesh) Combined Report for 1967-68 to 1969-70 (Delhi, 1974).
7. K.C. Barak, B.K.Chaudhuri and R.C. Chanda	:	West Bengal, Combined Report: 1954-55 to 19 (Delhi, 1963).
8. G.D. Agarwal	:	Uttar Pradesh, Combined Report 1954-55 to 1 57 (Delhi, 1963) covers Meerut and Muzzaffar districts.
9. B. Misra	:	Cuttack District (Orissa) Combined Report, 1967-70 (Delhi, 1974).
10. B. Sarveshwara Rao	:	West Godavari District (Andhra Pradesh), Combined Report: 1954-58 to 1959-60 (mimeo, 19
11. G.S. Lalvania	:	Deoria, Uttar Pradesh, Combined Report: 1966-69 (year not indicated).
12. A.S. Kahlon	:	Ferozepur District (Punjab) Three Year Consolidated Report 1967-68 to 1969-70 (Delhi, 1974).
13. V. Rajagoplan and M. ..	:	Coimbatore District, Tamil Nadu, Three Year Combined Report, 1970-71 to 1972-73 (Delhi, 1976)
14. V. Shanmugasundaram	:	Thanjavur District (Tamil Nadu) Combined Report 1967-68 to 1969-70 (Delhi, 1974).
15. Roshan Singh and Ranbir Singh	:	Muzaffarnagar District (Uttar Pradesh), Combined Report, 1966-67 to 1968-69 (Delhi, 1975).

Note: In the text the Combined Report are denoted in the footnotes as "C.R."

2/ In the early stages the FMS also tried an alternative technique called the Survey Model, which depended on the Sample farmers' recall of relevant information rather than records of actual transactions as in the Cost Accounting method. Subsequently, all FMS switched over to the latter method.

3/ In most districts one observes considerable year to year variations in area, yield as well as inputs. These variations do not always in a manner which would justify, their being assumed as "random" in nature. In many cases, the variables show systematic year-to-year changes even within the three-year period, over which the survey is conducted in each district, at a time.

4/ We have done this in the case of West Godavari (pooling size class-wise estimates the paddy and tobacco zones for all crops, and for irrigated and unirrigated paddy in two seasons) for Coimbatore (pooling data for canal and well-irrigated paddy) Sambalpur and Deoria (pooling data for all crops for two zones), Surat and Bulsar (pooling size class-wise data for paddy for 4 years). Unless the variations in agro-climatic conditions between zones and seasons within particular districts is much greater than across districts, such a procedure is not any less valid and reliable than the analysis based on inter-district cross-sections.

5/ GOI, Central Statistical Organisation, National Accounts Statistics, 1960-61 to 1974-75, Table 38.1 (New Delhi)

6/ GOI, Central Statistical Organisation, Statistical Abstract, 1975, (New Delhi) Table 17.

7/ The FMS reports for 12 districts (zones) give the share of by-products to total value of crop output. This share varies from less than 6 per cent in West Godavari (Tobacco Zone) to 30 percent in Pali.

8/ In 1967/8 and 1968/9 the total volume of Farm Yard Manure per farm averaged 17800 kg. and that with a nutrient content ($N_1P_2O_5$ and K) of 277 kg. See Muzaffarnagar CR, 1967-70, p.79.

9/ The ICAR estimates average nutrient content of bulky farm yard manure in India is 0.75% (compared to 2.3% in European countries). See, Indian Council of Agricultural Research, Handbook of Agriculture, (New Delhi, 1969) p.108.

10/ These include Ahmednagar, Nasik (1954-57), Deoria (1966-69), Muzaffarnagar (1966-69), Sambalpur (1957-60) and Hooghly, 24 Parganas (1954-57). We have assumed that since FMS issues uniform concepts and procedures in all other respects, the data on human labour in the above reports are also in terms of standard mandays.

11/ These include Ahmednagar, Nasik, Amritsar, Ferozepur, Hooghly, 24 Parganas, Meerut and Muzaffarnagar (all relating to 1954-57).