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LABOUR USE IN INDIAN AGRICULTURE: ANALYSIS AT MACRO LEVEL FOR THE EIGHTIES

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INTRODUCTION

Human labour use in Indian agriculture is likely to be a topic of significance for some time to come. This is particularly so since the last four decades witnessed little occupational diversification. A recent Planning Commission document on employment admits that, in the face of a population growth of 2 percent per annum through the last two decades, the bulk of the additional 100 million people who are likely to join the labour force in the nineties will have to find jobs in agriculture and allied activities (GOI 1990). To what extent can this be done, is a question often raised but seldom answered adequately. This paper aims to explain variantion in labour use in agriculture across regions and crops and thereafter judge the possibility of raising labour use in this sector at an all India level.

An impressive volume of literature has emerged at the micro level to identify factors that influence the quantum of employment in agriculture. Earlier (and some recent) studies based on the micro level analysis of Farm Management Surveys as well as other small sample inquiries suggest that the principal variants of labour use are, cropping intensity, cropping pattern, bio-technology application, mechanization, irrigation, land size distribution and a number of institutional factors (Bardhan 1977; ILO-ARTEP 1979; Agarwal 1980; Wickramasekara 1987; Parthasarthy 1990; Reddy 1989). Activity-specific

[1] Tata Institute of Social Sciences, Bombay. This paper was written when I was visiting the Institute of Social Studies (ISS) at the Hague during spring/summer 1991. It forms a part of a larger monograph on technical conditions in Indian agriculture during the eighties. Financial assistance received from the ISS is gratefully acknowledged. The author would also like to thank Professors Krishna Bharadwaj and Ashwani Saith for useful discussion.

labour demands too have been calculated for different agro-climatic zones, technologies and farm-sizes, which form the building blocks for constructing macro scenarios of employment in agriculture (Basant 1987)[1]. There are, however, few studies at the macro level -- fewer of recent origin -- which identify causalities or generate parameters that could help assess incremental labour use in this sector[2].

Some recent works (Bhalla 1987; Vaidyanathan 1986) concentrate on interpreting time trends and point comparisons in labour use (and also compute elasticities of employment with respect to time), to conclude that limits to the same are reaching in many areas[3]. Other cross-sectional studies find wide variations across crops and regions, which are interpreted as pointers to raise employment in the future (Mishra 1989; Gulati and Sharma 1990). These studies are restricted to establishing employment-output linkages which do not permit perceiving under what conditions such links hold.

This paper, written in a macro context, aims to analyze a recent data set -- the Cost of Cultivation Surveys (COC) -- for understanding the extent of labour use in crop agriculture across regions, crops and categories of workers and identify factors which explain variations in the same. It then goes on to seek possibilities of enhancing employment in this sector. A total of 14 crops grown in 15 states are covered for different years in the eighties. The exercise is cross-sectional for the period of the eighties[4].

The next section looks at the data matrices to judge the labour use pattern across crops and states and decipher from these, the nature and extent of (regional) variation. The following section then provides a possible a theoretical context to these observations in the light of the existing literature. Section 4 presents econometric estimates of the causal relationships evolved, and section 5 indicates possibilities of enhancing labour use. The paper ends with a conclusion in section 6.

LABOUR USE ACROSS CROPS AND REGIONS

The data sets used in this paper are drawn from the COC surveys, which are conducted by the Directorate of Economics and Statistics, Ministry of Agriculture, and pertain to the period of the eighties. These data, collected annually from over 9000 farms belonging to various size categories and agro-climatic zones, contain information on inputs and outputs. Owing to the (relatively small) size of the sample, disaggregation by farm-sizes is not advisable but state level aggregates for each major crop are fairly representative of the macro situation. These are not panel data, hence time series analysis is not permissible. But for cross-sectional studies they are eminently suitable[5]. The data are released (by the Directorate) in a format where all figures are, per-hectare state level averages. All the data presentations and analyses in this paper follow this definition. It needs mention that these data are the most comprehensive ones on crop labour use in India, in their expanse and coverage.

Data on standard person-days[6] worked in crop agriculture per hectare by crop and state, averaged for different years of the eighties, are given in table 1. Since not all crops are grown in all states, the table is accordingly drawn up. On an average, labour use in agriculture is not very high; the all crop aggregate being about 103 person-days (per crop) per hectare, compared to much larger figures of over 2-3 hundred in south-east Asia or over 400 person-days in Japan, Korea and Taiwan of the yester-years. Compared to the fifties and sixties though, labour use is higher in the eighties. Roughly half these are hired hands. The deviation in labour intensity is large; there are significant inter-crop and inter-state intra-crop differences, both for total and hired labour. It is implied that not only is each crop unique, the same crop deploys different doses of labour in different locales.

Crop specific figures show that paddy, sugar-cane, cotton and jute employ more workers than millets, pulses, wheat and mustard. The high labour use in certain crops is co-terminus with the fact that these crops are grown under irrigated or high rainfall conditions; on the converse the low labour using crops are grown under relatively dry conditions. The crop specific labour use pattern, to some extent, corresponds with the natural endowment pattern in a specific region. Hired labour shows a similar dispersion.

There is an association between the proportion of hired labour use and total labour use in the high labour using and/ or high marketed crops, namely paddy, cotton and sugar-cane, though there is no crop-wise discernable pattern. In cases of high labour use, the incremental labour is provided by hired hands rather than raising the labour participation from within the cultivating households. This provides opportunity for hired workers to obtain employment (and a share in income) in the event of a high labour demand.

The intra-crop differences in labour use across states are wide too. The variation in labour use in each crop between states could be as wide as 80-90 percent in most cases. A distinctive feature is the relatively high labour use in virtually all crops in the eastern and southern states compared to those in the north and west. The eastern and southern states are, traditionally, paddy growing areas and since paddy requires high degrees of crop husbandry, perhaps the overall choice of technology and land distribution are geared towards high doses of human labour there. This aspect is discussed later in the paper.

The distinctly backward states such as Assam and Madhya Pradesh (ie. those having low productivity levels), deploy fewer person-days of labour than the more advanced states, in all crops. The most advanced ones, namely Punjab and Haryana, however, do not necessarily deploy the highest labour doses; instead the labour abundant east where the productivity is not necessarily high, shows higher figures for the same crops. While the employment-output relationship holds in general, it does not necessarily follow a discernable pattern. A comparison of the productivity data (given in the last column of table 2) with the labour use data support this contention.

Following the conventional wisdom that labour use shows co-variation with the nature and extent of crop activity, data on select inputs and output have been presented in table 2. This table, when read in conjunction with table 1, shows some association between labour use and application of specific inputs. There is larger labour use in crops and states which apply higher doses of fertilizer and irrigation. The simple correlation coefficients between labour input on the one hand and fertilizer and irrigation on the other for the pooled sample are, 0.69 and 0.55 respectively[7]. The fact that irrigation and fertilizer are complementary in crop operations (correlation coefficient 0.73) suggests that modern technology of the bio-chemical type in the presence of irrigation promotes human labour use.

Bullock use does not show any significant association with the bio-chemical inputs but shows a statistically significant correlation with human labour use. Machine labour shows a significant positive correlation with bio-chemical inputs but a small negative one with employment. When bullock and machine labour inputs are pooled together, they show a significant positive correlation with all bio-chemical input variables but their association with human labour is not very high. These associations suggest that mechanical energy, so necessary for intensive crop operations, comes from bullocks when farmers operate under conditions of low (bio-chemical) input application. Machines begin finding a place when farmers have access to high doses of (bio-chemical) input. Human labour use is high under the former and not so high under the latter.

The last major observation from tables 1 and 2 relates to the close association between land rent (an indicator of the quality of land), output and inputs, including human labour. It is common knowledge in a country like India that land quality varies extensively across regions for natural as well as man-made reasons. Even within the same region land quality could vary, as a result the land use pattern is accordingly defined.

This section attempts to describe the data used in this paper, with the specific purpose of highlighting upon the inter-crop and inter-regional variations in labour use. The data show that in addition to region specificities, complementary and competing inputs influence the extent of labour use. The tables further show that hired labour is resorted to in the event of a high demand for labour, implying that factors affecting both are the same. This short description lays the foundation for developing an explanation for the regional and crop-specific labour use in crop agriculture.

AN ANALYTICAL FRAMEWORK

The wide variations seen in the data in the last section and the emergence of labour-saving technologies at an early stage of development deny acceptance of classical theses such as those formulated by Ishikawa (1981) here[8]. The two main approaches evolved in the Indian context are, those which explain labour use through its interface with institutional factors such as, farm size, tenurial conditions and factor prices[9], and those which measure the impact of modern technology. Data in the previous section suggest a strong region/ crop specificity and the role of technology/ endowments in determining labour use. In this section it is attempted to see what synthesis of these is most admissible.

The formulation that comes closest to the contentions here is the one conceived by Vaidyanathan (1978), who aims to explain inter-regional variation by arguing that (i) bio-chemical technology and soil moisture have the intrinsic capacity to raise land yields, (ii) physical (including human) energy inputs contribute to yields not directly but through bio-technology application and (iii) human labour use is governed by land yields and relative prices of different inputs. The approach (perhaps implicitly) assumes that institutional factors shape the technology package; there is no explicit mention to them. The author was not able to validate his results satisfactorily for a variety of reasons relating to formulation of testable propositions, quantification of variables and paucity of data.

In this study a modified Vaidyanathan thesis is propagated where a priori it is maintained that different regions and crops are on separate production functions; as a result, there is substitution as well as complementarity between different inputs. Since output is (definitionally) a function of a spectrum of inputs, labour use depends upon the output level and the way different inputs are combined. In its reduced form thus, for a given level of production, labour use would be governed by the combination of inputs and their prices. The input structure here includes disparate factors such as the quality of land and agro-climatics in addition to the conventional ones. Given this broad frame-work, it is argued that labour use in agriculture emerges through an interface of three groups of influences which are not necessarily mutually exclusive. These are, the place of agro-climatic region specificities and the associated crop regimes, the impact of modern technologies, and market influences. These aspects are discussed in detail in the following text.

Dissimilar agro-climatic zones have, for long, used labour diversely due to differential endowments. They have accordingly shaped farming systems which follow certain employment patterns. Traditional high rainfall areas -- which historically are also densely populated -- grow paddy in which higher labour units are deployed. In contrast, semi-arid zones -- which historically are also sparsely populated -- grow millets which require less water and crop husbandry, and thereby deploy less labour. In the course of time with the harnessing of irrigation and other facilities, both wet and dry areas have begun to grow a variety of crops and crop combinations along with their main crop(s). The dominant characteristics of each agro-climatic zone, which include evolution of methods to use or save labour advantageously, however, still prevail and new crops often fit into the extant farming systems. One thus observes that in the southern and eastern states of India, which receive high rainfall in many areas and mainly grow paddy, more labour is used compared to, say, in the northern states of Haryana, Madhya Pradesh and Punjab, which have of late begun to grow paddy (along with other crops). The same crop therefore shows different labour coefficients in these identified locations.

Several crops and crop combinations have labour demands which at times are jointly determined[10]. Cotton and sugar-cane have time-specific labour demands for which contracts are made well in advance. In contrast, coarse grains are not so time specific about their operations. Instances of complementary labour demands from crops grown in the same season (such as those in wheat and mustard) are also not unheard of. Such distinctions too affect overall labour use.

The second major influence is that of technology (and endowments), which for purposes of analysis can be studied under three types: the bio-chemical type process which initiates plant growth, irrigation which sustains it and mechanical type input which is the prime mover. Improvements in plant breeds or better care of normal breeds through fertilization, soil care and moisture maintenance, requires a change in the number and sequence of crop operations. The sheer quantum of work is large and highly time-specific, owing to which labour demand rises[11]. This demand gets a further boost because of informal contracts that farmers enter into with labourers for ascertaining uninterrupted labour availability. It goes without saying that this labour use is expected to be productive in the sense that the extra cost is expected to be more than compensated by increases in productivity.

Irrigation contributes to employment directly by creating jobs relating to water channelling, and indirectly through (i) exploiting HYV as well as normal seed varieties better and (ii) promoting multiple cropping. It may not be fully correct to equate HYV technology adoption with irrigation, as is often done, because normal crops are irrigated too. The converse is also true. The independent place of water in promoting employment needs recognition (Rao and Raju 1987; Satpathy 1984).

Mechanical energy in agriculture is used for a variety of operations such as tilling, sowing, inter-culture, irrigation and post-harvest operations. Usually, the crop yield is better when the soil is turned a number of times because this permits air to pass through the top soil which, in turn, helps better nitrogen fixation. Well irrigation too at times relies on bullocks and tractors. Higher doses of energy are thereby associated with higher output. This energy, when supplied by bullocks, raises employment since bullock power is necessarily accompanied by human labour use[12].

A digression would not be out of place at this stage. Excessive land fragmentation has not been found conducive to effective land use: very often the very small plots are under-used (Chadda 1987). De facto thus, bullock labour may also be associated with land consolidation and better land use[13].

Mechanical energy is also supplied by tractors and other similar machines, and more advantageously as seen from the data description earlier, but their sheer size and pace of operation replaces many human labour jobs[14]. While it may be true that the overall employment effect of a tractor on the local economy has been found to be inconclusive, individual jobs in crop operations do get replaced (Binswanger 1978; NCAER 1980). The two mechanical energy inputs, namely the bullocks and tractors, thus have opposite effects on employment.

In the same group of influences, the importance of land quality too can be appreciated. Instances of certain lands being agriculturally more fertile than others, are abundantly found in river delta regions, volcanic soil belts or on banks of rivulets. Quality of some lands is artificially enhanced too, by investment in earth works, soil treatment and watershed development. Because of the ability of these lands to preserve soil moisture and possess natural minerals, they provide opportunity to raise output and employment, independent of the larger agro-climatic zone in which they fall.

Last, market influences on labour use can best be expressed by the response of farmers to factor prices. Given the productivity of factors, farmers are expected to maximize profits by allocating their factors in accordance with prices. The relation of wage rates to labour use in this regard is expected to be negative; even for own labour if the notion of opportunity cost of labour exists[15].

A word about some institutional factors needs mention here. Size distribution of plots, share-cropping and land renting do influence labour use, but the mechanism of their operation is through land use and physical input application. For example, when it is found that small farmers deploy more labour, it is through substitution of other factors by own labour. Small farms could also use more labour because they are more productive; but once again the mechanism operates through higher material/ energy input application, or the intrinsic quality of small plots is good[16]. The argument can be extended to explain the relatively low labour use on share-cropped or rented lands. Thus while institutional factors could be the motivators in determining the intensity of cultivation, they are per se not the direct determinants of employment. Their role can best be appreciated by first assessing their impact on land use and input application and then determining the impact of the latter on labour use. This two-step procedure is however not pursued in this exercise since such an approach would require considerably higher disaggregation than that being attempted here[17].

This section develops an analytical frame-work which draws upon the patterns observed in the previous section as well as arguments developed on this subject in the literature. The approach suggests that the major variants of employment are, the agro-climatic/ crop regimes (and land quality), form and composition of technology package and factor prices.

EMPIRICAL EVIDENCE

Identification of Variants

The hypothesis discussed in section 3 is tested here using the Ordinary Least Squares (OLS) method on a cross-section of 327 observations drawn from COC state level aggregates[18]. The model is tested separately for total as well as hired labour. The dependent variables in the two equations are, the total and hired labour used (in person-days) per hectare in crop operations, respectively.

The notion of uniqueness of crops and regions is captured by a system of dummy variables. The most appropriate method would have been to identify zones *a priori* and then suitably label them. However in the absence of data to identify them, the observation (from section 2) that the southern and eastern states employ more labour, is used for identifying regions. A regional dummy variable assumes a value unity for southern and eastern states and zero otherwise[19]. The crops are grouped into five broad categories based on the logic of seasonality, marketability and the extent of labour demand in crop activity. Each is represented by a dummy variable. The identity of paddy is maintained since it is a high labour using crop, often grown under subsistence conditions and not necessarily for marketing (crop dummy 1). The rabi (winter) crops -- wheat, gram and mustard -- at times inter-cropped and often part of a farming system, form the next group (crop dummy 2). Sorghum, bajra and maize, all coarse cereals, mainly grown for home consumption and not requiring much crop nutrition or energy input, are clubbed together (crop dummy 3). The three kharif pulses, namely, moong, urad and tur, again grown under similar conditions, are grouped together (crop dummy 4). Lastly, cash crops -- cotton, sugar-cane, jute and groundnut -- form a group, as they find similarity in (high) labour use, marketability of the product and highly time-specific labour demand (crop dummy 5)[20]. Regions and crops are thus represented by a system of 6 dummy variables.

Based on the logic that land is valued according to its yield, which in part is due to the intrinsic quality, land rent is taken to represent the quality of land. The prevailing rent (in rupees per hectare) for own plus leased land is used to proxy for this variable.

Bio-chemical technology is measured by the value of fertilizers and manures applied per hectare of cropped area. Measurement of irrigation poses a problem. Not only are various modes of irrigation priced differently, the same mode is priced dissimilarly across regions. Added, are the problems of unequal water requirements in different agro-climatic zones as well as of different crops in the same region. The COC data provide the monetary cost incurred on irrigation per hectare. However, since irrigation is vital to south Asian agriculture, the cost incurred is used as a proxy to capture its impact.

The two energy inputs are represented by the respective rupee expenditures incurred on them per hectare. The first includes all expenses incurred in using bullocks during crop operations and the latter includes the same on tractors and threshers.

Finally, market influence (factor price) is represented by the (hourly) wage rate paid. While this may not be the best method to do so since this variable could have a high (and spurious) correlation with the dependent variable owing to the fact that these data are ex-post, the variable is still retained since a scatter showed that the variation in wage bill is larger than that in labour use[21]. Further, the correlation between labour use and wage rate is not found high enough to term it as a 'dominant variable' (Rao and Miller 1973). Cross price elasticities of different factors have been neglected since they are not expected to be significant (Kumar and Mruthyunjaya 1987).

A word about the data set is necessary here. There are some inputs which are not necessarily priced. COC surveys attach market values to them. There is no visible bias originating in measurement, but there could be imposition of market relations which may not exist in real life.

The Estimates

The estimated equations of all crops, for total and hired labour use respectively, are given are as follows[22]:

$$(1)\ HL = \underset{}{196.25} + \underset{(6.54)}{0.79\ BL^*} - \underset{(5.48)}{0.74\ ML^*} + \underset{(7.06)}{0.37\ F^*} + \underset{(5.92)}{0.62\ I^*} + \underset{(3.47)}{109.76\ SD^*}$$

$$+ \underset{(5.15)}{0.14\ LQ^*} - \underset{(3.40)}{137.60\ W^*} + \underset{(3.86)}{174.20\ CD1^*} + \underset{(2.05)}{88.98\ CD3^*} + \underset{(1.89)}{87.50\ CD4^*}$$

$$+ \underset{(8.93)}{369.71\ CD5^*}.$$

$$R2 = 0.80 \qquad F = 112.48 \qquad N = 327$$

$$(2)\ HHL = 58.83 + \underset{(1.17)}{0.12\ BL} - \underset{(5.90)}{0.67\ ML^*} + \underset{(9.67)}{0.42\ F^*} + \underset{(6.42)}{0.56\ I^*} + \underset{(6.51)}{172.64\ SD^*}$$

$$+ \underset{(5.13)}{0.11\ LQ^*} - \underset{(2.89)}{98.01\ W^*} + \underset{(3.07)}{114.52\ CD1^*} + \underset{(1.42)}{51.68\ CD3} + \underset{(2.19)}{84.74\ CD4^*}$$

$$+ \underset{(5.08)}{176.09\ CD5^*}.$$

$R2 = 0.81$ $F = 122.23$ $N = 327$

where, HL= human labour (persondays per ha), HHL= hired human labour (persondays per ha), BL= bullock labour (Rs per ha), ML= machine labour (Rs per ha), F= fertilizer (Rs per ha), I= irrigation (Rs per ha), SD= region dummy, LQ= land quality (Rs per ha), W= wage rate (Rs per hour) and CDi= crop group dummies. Figures in the brackets are the respective 't' values. * denotes significance at 5 percent confidence.

Equation (1) is a good fit which explains 80 percent of the variation in total labour use. All variables, including dummies, show significance at 5 percent confidence level and bear the expected signs[23]. Among the real variables the coefficients of bullock labour, fertilizer use and irrigation have positive signs while those of machine labour and wage rate show negative signs. The magnitudes of the dummy variables too are as expected. The region dummy shows a positive value, which complies with the earlier observation that the eastern and southern states employ more labour in general than others for each crop (or crop group). The rabi crop dummy has been eliminated[24] in the estimation procedure since it represents crops which employ least labour. All other dummy coefficients are positive and have a magnitude in correspondence with the quantum of labour used by the crop groups.

Equation (2) is a good fit too, which explains over 80 percent variation and shows characteristics similar to those of equation (1). The bullock labour variable, though, is significant only at 15 percent confidence level, which is too low to be acceptable. Bullocks in south Asian peasant agriculture are not handled by hired hands: they are almost wholly manned by owner cultivators. Equation (2) was fitted again after dropping bullock labour; the result is as follows as:

$$(3)\ HHL = 97.51 - \underset{(6.11)}{0.69\ ML^*} + \underset{(9.93)}{0.43\ F^*} + \underset{(6.31)}{0.55\ I^*} + \underset{(6.48)}{171.74\ SD^*} + \underset{(5.11)}{0.11\ LQ^*}$$

$$- 96.42 W^* + 117.19 CD1^* + 46.32 CD3 + 70.45 CD4^* + 170.65 CD5^*.$$
$$(2.85) \quad (3.10) \quad (1.29) \quad (1.92) \quad (4.96)$$

$R2 = 0.81$ $F = 134.16$ $N=327$

This equation now shows all variables other than a crop group (coarse grain) dummy significant at 5 percent confidence; this dummy is significant at 10 percent confidence. The coefficient values here are very similar to those in equation (2), implying that the reason for the insignificance of the bullock labour variable is not implausible.

The equations were also fitted separately for each crop group, for both, total and hired labour. These results are given in tables 3 and 4 respectively[25]. Table 3 shows that out of 35 coefficients, 23 are statistically significant and have the correct signs. Table 4 shows 19 significant coefficients. Analysis of table 3 indicates that the first group (paddy) does not show irrigation, machine labour and land quality to be significant. The second group (rabi crops) shows machine labour to be insignificant. The third group (coarse grains) does not show machine labour, irrigation and the state dummy to be significant. The fourth group (kharif pulses) shows machine labour, fertilizer, irrigation and state dummy to be insignificant. The last group (cash crops) shows wage rate to be not significant. Table 4 does not show much deviation from table 3 except for the relatively low importance of bullock labour and the high importance of the wage variable in all equations, which is an expected result.

The reasons for some variables not showing statistical significance in some crop group equations are related to the specific characteristics of these groups. These characteristics are as follows: (i) Most kharif crops are scantily served by irrigation (in its present definition there are many zero values in the data); (ii) Crops other than high value ones scarcely use machine labour; (iii) Cash crops usually require highly time-specific labour inputs and farmers do not hesitate to pay (or put in their own labour) since returns are high in these crops; and (iv) Insufficient number of observations on specific crops make region dummies insignificant in some crop groups. Part of the reason for the statical insignificance of some variables also lies in the fact that the sample sizes in these equations are relatively small and multicollinearity raises the standard errors of coefficients. Since the effect of multicollinearity varies inversely with the sample size, this problem is acute here when compared with equations 1,2 and 3 (Rao and Miller 1973).

The hypothesis developed through sections 2 and 3 find support in the multivariate analysis, both for total and hired labour use. It is also seen that the propositions evolved in the earlier studies related to labour use (discussed in the introduction), still hold good in the eighties. A distinctive feature of these estimates over those of Vaidyanathan and most others is the higher degree of explanation and significance of all the variables projected to explain variation in labour use.

THE IMPLICATIONS

The implications of this empirical exercise are discussed here through a scrutiny of the coefficients. Elasticities at means, calculated from equations (1) and (3), are given in table 5. Individual elasticities are all less than unity; in fact the sum of these are 0.46 and 0.37 for total and hired labour, respectively. (When weighted by area under each crop, these figures fall to 0.36 and 0.30 for total and hired labour, respectively). Even if all the variants double, the rise in employment (both total and hired) would be less than half that proportion. Though there is a possibility of raising employment in agriculture, it is not very high.

Tyagi (1981) worked on a time-series of the seventies to arrive at an employment-output elasticity of 0.77. Bhalla (1987) reached a figure of 0.59

from a slightly later time series (1971-72 to 1983-84). The elasticity estimates here are not strictly comparable with those of Bhalla or Tyagi since the methodologies are different, but since these also are elasticities of labour use for all crops, a crude comparison can be made (under an assumption that the cropping pattern and the inter-crop input use pattern would stay unchanged). Such a comparison shows a secular fall over time.

These figures on the one hand provide legitimacy to cross-sectional analysis if the specification is appropriate, and on the other support the opinion that the capacity of agriculture to absorb labour is not indefinite.

Individual elasticities of equations (1) and (3) show that the response to hired hands is greater than that to total labour with respect to every variable. If the demand rises, hired hands are taken in first, and by the same token, they are also retrenched first.

The bullock input elasticity figures show that it provides the maximum impetus to labour use. However data in section 2 shows that there is a tendency to replace draught animals by machines with the advent of modern bio-chemical technology. This aspect, reflected in the multi-variate analysis by the negative coefficient of machine labour, could undermine the effect of animal labour on employment. If animal labour use is also a reflection of the extent of land consolidation of very small fragments, then one is on a firmer -- though different -- footing to say that better land use pattern through consolidating such holdings would be labour using.

The land rent elasticity suggests that augmenting land quality through earth works, watersheds, soil conservation, terracing and similar means can visibly promote employment. In fact the most common project undertaken by the Government under its poverty alleviation schemes is that of earth works. If these projects are carefully designed to raise land quality, the multiplier effect could be significant.

Taken in isolation, fertilizers and irrigation can be significant promoters of labour use, but as mentioned earlier, it may not be possible to do so unless there is a strong intervention by the state in factor markets, which is not likely or feasible.

Last, a rise in wages is detrimental to employment but a freeze in wages can seriously affect levels of living of hired labour, who form the poorest section in rural India. There is thus need to raise efficiency and productivity of physical inputs at a pace which outstrips the (negative) wage effect.

The overall results show that there is still a potential for labour use in agriculture in the future since some factors are positive promoters. It may however be increasingly be difficult to absorb more labour over time as modernization brings in retarders as well.

CONCLUSION

This paper attempts to re-look at the debate on labour use in Indian agriculture to identify factors underlying it, and estimate their impact on labour use at the all India level. The broad results are summarized below:

(1) The extent of labour use varies extensively across crops and states. The main reasons are, the individual characteristics of each crop, inter-state differences in farming systems and the levels of development.

(2) Hired labour is used more extensively in crops which use more labour in their crop operations. Closer examination reveals that there is a backward bending labour supply curve among land owners which permits hired hands to obtain more jobs.

(3) The broad approach developed here to explain labour absorption proposes that its use in agriculture is contingent upon modernization of agriculture, labour promoting and displacing technologies, natural endowments, wage rates

and the locally prevalent farming systems. Labour use depends upon both technological and market characteristics.

(4) The econometric model supports the hypothesis developed. This approach, being considerably disaggregated, permits identification of labour use promoters and retarders, unlike the employment-output linkages established elsewhere in the literature.

(5) The estimates suggest that there is yet a possibility to promote labour use in Indian agriculture, though a comparison with other researches shows that it is receding over time. Some options to do so are by improving land quality through earthworks and watershed development, agricultural modernization through irrigation and use of modern varieties, and keeping productivity growth in line with wage increases.

TABLE 1

Total and Hired Labour Days (Per Ha) by Different Crops in Each State

Crop/State	Total	Hired	Crop/State	Total	Hired
(1)	(2)	(3)	(4)	(5)	(6)
Paddy			Sgr.Cane(continued)		
A.Pradesh	173.56	142.95	Maharashtra	411.60	335.15
Assam	94.48	29.09	T.Nadu	380.05	349.50
Bihar	122.64	68.18	U.Pradesh	156.17	37.58
Haryana	98.02	64.13	Jute		
Karnataka	141.11	85.91	Assam	208.05	100.16
M.Pradesh	82.53	43.68	Bihar	127.72	84.51
Orissa	144.49	87.86	Orissa	226.44	101.77
Punjab	119.18	81.18	W.Bengal	224.12	117.76
T.Nadu	182.12	160.96	Moong		
U.Pradesh	126.05	56.63	A.Pradesh	62.39	44.59
W.Bengal	164.66	96.79	M.Pradesh	52.09	18.52
Wheat			Maharashtra	53.04	28.95
Bihar	105.17	48.38	Orissa	51.63	23.94
Haryana	55.39	21.71	Rajasthan	51.48	6.94
H.Pradesh	49.55	7.01	Tur		
M.Pradesh	52.42	23.46	Karnataka	54.57	31.45
Punjab	59.24	34.97	M.Pradesh	62.97	17.98
Rajasthan	81.75	16.42	Maharashtra	92.22	36.08
U.Pradesh	88.38	33.10	U.Pradesh	97.63	33.53
Jowar			Urad		
A.Pradesh	57.73	38.90	A.Pradesh	47.52	38.49
Gujarat	68.10	34.47	M.Pradesh	58.19	21.47
Karnataka	59.81	34.95	Maharashtra	90.19	49.35
M.Pradesh	56.04	23.50	Orissa	51.36	26.41
Maharashtra	89.10	43.97	T.Nadu	62.46	50.03
Maize			U.Pradesh	72.27	16.70
Bihar	132.24	53.41	W.Bengal	87.82	36.35
H.Pradesh	70.76	5.10	Gram		
M.Pradesh	65.66	21.89	Haryana	26.79	8.36
Rajasthan	88.47	12.46	M.Pradesh	46.16	21.16
Bajra			Rajasthan	35.72	6.78
Gujarat	93.94	46.86	U.Pradesh	74.13	19.77
Haryana	48.33	8.42	Gr.Nut		
Maharashtra	112.81	97.68	A.Pradesh	98.59	76.14
Rajasthan	33.77	6.94	Gujarat	71.05	35.32
U.Pradesh	82.79	31.36	Karnataka	81.81	52.65
Cotton			M.Pradesh	72.95	32.25
Gujarat	147.62	92.12	Orissa	157.79	79.12
Karnataka	124.26	98.99	T.Nadu	121.00	92.47
M.Pradesh	80.23	41.66	Mustard		
Maharashtra	109.11	63.50	Assam	83.02	17.25
Punjab	117.97	54.04	Haryana	39.09	8.09
Sgr.Cane			Punjab	47.56	16.40
A.Pradesh	359.63	320.81	Rajasthan	53.63	7.78
Bihar	139.90	92.81	U.Pradesh	71.08	21.64
Haryana	142.59	49.43			
Karnataka	241.86	178.71			

TABLE 2

Selected Inputs Used and Output in Different Crops (1980-88), By States

Crop/State	Fert./Ha	Irr./Ha	BL/Ha	ML/Ha	Ld Rt/Ha	Prdn/Ha
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Paddy						
A.Pradesh	126.84	142.62	167.57	103.30	1323.37	33.40
Assam	0.62	0.18	263.00	1.30	591.67	18.25
Bihar	24.03	28.25	242.19	3.30	952.62	18.21
Haryana	123.45	546.49	33.78	331.99	1109.21	35.23
Karnataka	83.85	58.73	149.60	20.88	1208.36	34.50
M.Pradesh	22.77	8.51	148.80	6.75	632.77	13.83
Orissa	21.47	9.80	276.61	2.56	783.77	18.47
Punjab	177.69	592.43	30.23	358.39	1818.97	53.26
T.Nadu	136.65	217.46	216.04	82.27	1319.01	36.59
U.Pradesh	45.07	108.19	127.14	47.35	722.25	21.53
W.Bengal	31.01	35.66	234.76	3.69	1090.54	22.94
Wheat						
Bihar	46.85	124.55	268.22	22.09	1397.78	21.14
Haryana	123.90	257.08	59.75	415.09	976.83	27.52
H.Pradesh	27.49	1.60	113.98	115.14	594.54	11.80
M.Pradesh	30.94	125.25	139.13	51.79	702.98	12.51
Punjab	166.46	136.12	24.15	475.04	1647.92	32.04
Rajasthan	48.46	304.75	108.45	262.28	912.02	23.53
U.Pradesh	96.92	234.53	141.09	300.42	894.52	25.13
Sorghum						
A.Pradesh	13.02	10.88	117.65	7.07	384.38	5.94
Gujarat	18.99	67.29	73.74	38.82	367.25	7.23
Karnataka	14.67	9.28	91.86	11.69	309.64	8.46
M.Pradesh	7.57	0.83	124.03	9.45	351.95	7.84
Maharashtra	20.83	19.96	129.34	24.42	327.27	8.04
Maize						
Bihar	33.09	109.92	178.06	0.47	1290.72	22.25
H.Pradesh	29.66	0.95	88.79	39.61	580.19	13.55
M.Pradesh	25.35	6.49	101.17	8.93	395.01	8.54
Rajasthan	21.91	37.96	112.49	13.06	446.83	10.11
Bajra						
Gujarat	39.38	168.44	71.54	116.16	533.22	11.11
Haryana	6.44	38.04	51.98	72.30	441.85	7.12
Maharashtra	12.18	9.41	156.04	22.66	239.04	4.84
Rajasthan	0.75	9.92	29.58	31.24	153.42	3.91
U.Pradesh	17.55	19.71	112.12	74.02	599.40	13.06
Cotton						
Gujarat	113.41	290.34	91.33	177.55	907.85	10.08
Karnataka	105.38	17.82	88.13	89.78	1295.49	10.99
M.Pradesh	30.50	63.51	109.17	7.67	816.59	5.64
Maharashtra	43.85	19.79	142.84	19.61	331.03	3.89
Punjab	51.99	107.84	46.26	184.90	1168.27	9.81
Sgr.Cane						
A.Pradesh	257.00	620.81	87.73	85.00	4722.44	738.55
Bihar	24.06	114.04	214.29	2.34	2754.21	417.42
Haryana	110.23	275.72	58.09	86.22	1415.80	353.83
Karnataka	290.06	316.27	111.90	15.28	3728.03	830.47
Maharashtra	457.02	824.99	103.14	112.50	2443.55	845.88

TABLE 2 (continued)

Selected Inputs Used and Output in Different Crops (1980-88), By States

Crop/State	Fert./ha	Irr./ha	BL/ha	ML/ha	Ld Rt/ha	Prdn/ha
(1)	(2)	(3)	(4)	(5)	(6)	(7)
T.Nadu	280.36	916.66	82.48	58.85	2794.83	960.80
U.Pradesh	81.79	353.57	67.60	73.01	1569.27	403.73
Jute						
Assam	0.67	0.00	257.94	0.00	681.44	13.00
Bihar	6.59	16.49	166.93	9.23	803.49	11.13
Orissa	28.02	10.23	170.24	0.00	1158.23	17.66
W.Bengal	26.11	15.69	248.42	6.94	1302.49	17.21
Moong						
A.Pradesh	7.69	0.01	109.35	3.92	414.90	4.17
M.Pradesh	10.52	9.10	106.15	10.74	345.22	3.45
Maharashtra	7.12	0.10	81.47	5.28	110.77	1.98
Orissa	1.04	2.35	129.08	1.09	372.21	3.24
Rajasthan	0.31	1.76	50.22	22.91	163.03	1.93
Tur						
Karnataka	8.53	0.45	81.88	0.08	358.87	4.55
M.Pradesh	14.25	3.23	73.31	12.82	567.76	6.48
Maharashtra	23.56	8.35	131.03	9.63	167.73	4.14
U.Pradesh	5.10	20.67	105.87	52.67	1240.93	12.64
Urad						
A.Pradesh	2.32	1.44	40.71	24.01	484.68	4.81
M.Pradesh	11.18	0.84	122.70	1.13	397.43	3.98
Maharashtra	8.02	0.00	107.73	10.92	145.35	2.82
Orissa	0.50	0.61	112.70	0.00	476.88	4.75
T.Nadu	6.00	24.45	63.84	13.42	706.66	5.11
U.Pradesh	9.90	27.05	91.82	66.59	564.55	4.63
W.Bengal	0.00	0.00	247.22	0.00	661.09	6.99
Gram						
Haryana	0.86	38.24	52.94	61.36	596.41	5.43
M.Pradesh	6.09	25.55	137.94	16.07	591.60	6.04
Rajasthan	2.08	34.75	56.71	49.33	406.73	6.23
U.Pradesh	2.71	39.80	168.59	48.75	794.41	10.13
Gr.Nut						
A.Pradesh	26.09	36.37	152.69	3.98	769.29	6.75
Gujarat	54.58	104.63	76.20	79.96	649.80	7.53
Karnataka	23.41	12.03	108.60	5.65	592.96	7.33
M.Pradesh	19.06	0.38	118.08	0.00	661.68	8.94
Orissa	23.02	0.53	198.88	6.52	1277.71	11.27
T.Nadu	20.03	221.80	125.98	24.76	932.59	11.38
Mustard						
Assam	3.02	0.00	255.53	0.00	523.58	5.27
Haryana	41.75	119.45	62.88	202.10	902.32	9.53
Punjab	55.58	82.81	27.22	222.46	1401.67	8.38
Rajasthan	8.04	150.08	63.78	102.56	661.12	8.31
U.Pradesh	20.53	95.21	119.54	89.16	889.02	8.73

Note: Fert=fertilizer in Kilograms; Irr=irrigation cost at 1980-81 prices; BL=bullock labour cost at 1980-81 prices; ML=machine labour cost at 1980-81 prices; Ld Rt=land rent at 1980-81 prices; Prdn=production in quintals, and ha=hectare.

TABLE 3

Regression Estimates of Total Labour Use Per Hectare by Crop Groups

Variants	Group 1	Group 2	Group 3	Group 4	Group 5
(1)	(2)	(3)	(4)	(5)	(5)
Constant	550.66	226.95	449.21	411.52	463.54
Bullock Lab	1.27*	0.54*	0.67*	0.71*	1.23*
	(4.62)	(8.54)	(3.71)	(3.96)	(3.02)
Machine Lab	0.26	-0.13	-0.03	0.62	-1.32*
	(0.27)	(1.13)	(0.05)	(1.03)	(2.01)
Fertilizer &	0.46*	0.19*	0.32*	0.28	0.28*
Manure	(3.66)	(2.35)	(1.50)	(1.22)	(2.69)
Irrigation	0.13	0.35*	0.35	-1.28	1.01*
	(0.24)	(4.05)	(1.05)	(1.14)	(4.32)
Land Qty	0.01	0.07*	0.29*	0.16*	0.13*
	(0.07)	(2.74)	(3.85)	(2.53)	(2.31)
Wage	-362.04*	-96.77*	-342.93*	-238.70*	-152.60
	(4.10)	(6.17)	(3.60)	(3.28)	(0.97)
State Dummy	81.34*	233.69*	-9.39	-16.74	150.55*
	(1.76)	(8.92)	(0.20)	(0.57)	(1.65)
R2	0.75	0.85	0.70	0.58	0.66
F	16.01	58.41	15.16	8.53	24.49
N	46	81	53	52	95

* denotes significance of a variable at 5 percent confidence.

Note: Group 1 includes paddy, group 2 includes *rabi* crops (wheat, gram and mustard), group 3 includes coarse grains (sorghum, *bajra* and maize), group 4 includes *kharif* pulses and group 5 includes cash crops (cotton, jute, sugarcane and groundnut.

TABLE 4

Regression Estimates of Hired Labour Use Per Hectare by Crop Groups

Variants	Group 1	Group 2	Group 3	Group 4	Group 5
(1)	(2)	(3)	(4)	(5)	(5)
Constant	289.84	87.74	212.16	226.19	218.39
Bullock Lab	0.96*	0.01	0.53*	-0.05	0.28
	(2.96)	(0.38)	(3.74)	(0.38)	(0.90)
Machine Lab	0.74	-0.43*	0.53	0.13	-0.37
	(0.65)	(5.71)	(1.30)	(0.27)	(0.73)
Fertilizer &	0.68*	0.40*	-0.02	0.23	0.35*
Manure	(4.55)	(8.14)	(0.12)	(1.29)	(4.43)
Irrigation	-0.21	0.04	0.46*	0.55	0.90*
	(0.34)	(0.69)	(1.93)	(0.63)	(5.00)
Land Qty	-0.03	0.08*	-0.04	0.10*	0.09*
	(0.26)	(5.23)	(0.76)	(1.89)	(2.17)
Wage	-387.26*	-40.79*	-231.19*	-122.90*	-215.35*
	(3.72)	(4.15)	(3.42)	(2.15)	(1.79)
State Dummy	74.38	12.72	145.69*	108.90*	340.42*
	(1.36)	(0.78)	(4.25)	(4.71)	(4.85)
R2	0.72	0.79	0.59	0.48	0.78
F	14.41	39.01	9.24	5.75	45.08
N	46	81	53	52	95

* denotes significance of a variable at 5 percent confidence.

Note: Group 1 includes paddy, group 2 includes _rabi_ crops (wheat, gram and mustard), group 3 includes coarse grains (sorghum, _bajra_ and maize), group 4 includes _kharif_ pulses and group 5 includes cash crops (cotton, jute, sugarcane and groundnut.

TABLE 5

Elasticities at Means as Obtained From Equations (1) and (2)

Variables	Equation 1	Equation 3
(1)	(2)	(3)
Bullock Labour	0.31*	-
Fertilizer & Manure	0.16*	0.35*
Irrigation	0.10*	0.18*
Machine Labour	-0.09*	-0.16*
Land Quality	0.18*	0.27*
Wage	-0.20*	-0.27*

* denotes significance of a variable at 5 percent confidence.

END NOTES

1. The Indian Journal of Agricultural Economics devoted substantial sections on these issues in 1981 and again in 1987. The Journal continues to attach high priority to contributions on labour. Differing sample frames and methodologies, though, have not permitted a synthesis to emerge.

2. Some notable exceptions are, Alagh, Bhalla and Bhaduri (1978) and Bhalla and Tyagi (1989). But their methodologies at best permit explanation of labour/ land ratios across regions rather than actual labour use.

3. There are methodological problems associated with interpreting time series in the studies quoted here. Bhalla derives conclusions from data which are not panel series while Vaidyanathan uses data which do not necessarily reflect actual labour use.

4. Tyagi (1981) argues that cross-sectional elasticities could be spurious since different regions have non-replicably different characteristics. But if the regional characteristics are accounted for in the formulation, this objection would not hold any more.

5. These surveys collect data from farms representative of a region. The data are collected each year but the same regions are not necessarily visited the next year; instead the regions are rotated. Averages over different years provide a wide and representative cross-section as long as the years are not very wide apart.

6. Standard person-days are calculated by the COC authorities by equating each day worked by an adult woman worker equivalent to 3/4th of that of an adult male worker and that worked by a child worker equivalent to 1/2 of an adult male worker. The method followed by the earlier FMS studies was also the same.

7. All correlations mentioned in this section refer to the pooled sample unless otherwise specified. A reference to the pooled sample implies an overall association which can be generalized.

8. The Ishikawa theory, which propagates a strong association between labour use and land productivity owing to emergence of labour-using technologies, was developed in the context of the Far-East in the early/ mid twentieth century where paddy was the principal crop grown, in mild agro-climatic conditions and high rainfall. Land plots were small and evenly distributed and there was virtual absence of labour saving devices. None of these premises hold in today's agriculture. Bhalla (1987) examines the Ishikawa thesis in the Indian context to conclude that it does not fit the data. Labour saving technologies have been in use everywhere in today's world. A survey of the contemporary state of (labour saving) technologies in rural Asia can be seen in Jayasuryia and Chand (1986). Other aspects of land/ resource use are discussed in Jose (1986) and Wade (1982).

9. Bardhan (1978, 1973), among others, has tested the impact of institutional variables on labour use, but the frame-work evolved is restricted to a micro setting.

10. Agricultural scientists, in micro experiments, have evolved crop combinations which would maximize employment. Several papers in ILO-ARTEP (1979) are devoted to this aspect. Our purpose here is limited to identifying groups of crops which could have joint labour demands.

11. The extent of change in labour demand varies with crop and region. A prominent research piece where such a calculation has been made is, Mehra (1976).

12. Vaidyanathan seeks to establish substitution between human and bullock labour though most of his correlation coefficients are positive significant or insignificant. From this, our hypothesis gains further strength. Our formulation also seeks to establish the independent role of energy variables in promoting employment, a feature not accepted by Vaidyanathan.

13. Significant portions of land are uneconomically atomized in many parts of India. Chadda (1987) finds attempts at land consolidation to have yielded positive results.

14. Indian tractors, unlike those in south east Asia, are characterized by their extra-ordinary large size compared to land holdings. One of the reasons is the hard soil surface which does not easily break with lesser doses of energy. More pertinent however is the nature of international technology contracts which permit these large machines to be manufactured/imported in the country without much heed to farmers' needs.

15. Farmers' response to factor markets has been observed in several village studies. See World Bank (1989).

16. Farm size, productivity and labour use have been debated for long in India. The best references for immediate recall are, Bharadwaj (1974) and Rudra and Sen (1980).

17. It is virtually impossible to add up of the diverse institutional arrangements. These are best dealt in micro economic exercises only.

18. Since the data are in 'per hectare' form and belong to a cross section, it does not seem necessary to correct for heteroscedasticity or autocorrelation.

19. Attempt was made to empirically identify the number of intercepts needed to to define the regions. The south and the east clearly stood apart as a group but the north and west did not show that homogeneity. But attempts to introduce seperate dummies for the north and west did not help raise the total explanation. Hence only one dummy variable was retained.

20. It may seem inappropriate to club together all the cash crops in a single group but disaggregation of this group did not change the results. In fact the total explanation did not rise even when a dummy was introduced for each crop.

21. Most authors tend to use the prevailing village wage rate when they deal with farm level data. This is not possible in a macro exercise since labour markets in most developing countries tend to be highly localized and there are considerable variations within regions.

22. Log linear as well as double log formulations were attempted. The explanation in the log linear equation was relatively low while in the double log equation it was the same. However some degrees of freedom were lost in the double log formulation since there are some zero values in the data. The linear form is thus maintained.

23. Equation (1) was seperately estimated without any dummy variable as well as without the region dummy and the crop dummies alternatively, to determine the impact of dummy variables. The estimates are as follows:

1a) HL=371.07+0.74BL-1.25ML+0.47F+ 0.58I+ 0.23LQ-236.78W. $R2=0.72$
(5.72) (8.97) (8.04) (4.89) (8.04) (3.58)

1b) HL=271.01+0.79BL-0.97ML+0.44F+ 0.75I+ 0.16LQ-202.99W+233.53SD. $R2=0.76$
(6.54) (7.11) (8.12) (6.63) (5.54) (3.29) (7.10)

1c) HL=224.07+0.78BL-0.85ML+0.37F+ 0.56I+ 0.16LQ-205.49W+204.42CD1+83.19CD3
(6.33) (6.34) (7.08) (5.35) (6.30) (3.50) (4.53) (1.89)
87.55CD4+381.35CD5.
(1.86) (9.08) $R2=0.78$

These equations show that the dummies contribute upto 8 percent in the total variation in HL. The region dummy contributes upto 4 percent in the absence of the crop dummies and the crop dummies contribute upto 6 percent in the absence of the state dummy. When one dummy (or set) is dropped its (their) impact tends to partially get captured by the other(s). These equations also show that in the absence of dummy variable(s), the magnitude of the coefficients of many real variables tends to rise, indicating a bias in the specification without them.

24. It is the usual practice to include n-1 dummies to represent n intercepts. The variable with minimum level of tolerance is deleted.

25. Crop specific regressions were fitted too. There were many multi-collinearity problems owing to small number of observations. In totality the results were unchanged and hence they are not presented.

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