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# Agricultural mechanisation and labour use: a disaggregated approach[1]

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## Introduction

The debate on the employment implications of agricultural mechanisation in South Asia is now an old one. Yet, in spite of a proliferation of studies,[2] there are still gaps in our knowledge about the exact effects. One major shortcoming of many previous studies is their aggregative approach.[3] Most have limited themselves to considering the effect (principally of tractors) on total farm employment, failing to take account of the fact that mechanisation is essentially a mixed package. Different operations and crops allow different mechanisation alternatives, which are likely to have varying implications.

A disaggregation by operations becomes particularly important in the case of a multi-purpose technique such as a tractor which, even in the cultivation of a single crop, lends itself to a wide range of agricultural operations, such as soil preparation, sowing/manuring and the powering of irrigation pumps, harvesters and threshers. A farmer may, however, choose not to utilise it for all the functions it is capable of performing, and its actual use could vary from farm to farm. The flexibility increases further when we consider that a farmer could hire a tractor for specific operations. Its employment effects would differ depending on both the nature and the number of operations it performed. Similarly, disaggregation by crops becomes important because different crops lend themselves to different levels of tractor use. Failure to disaggregate the effects of a technique by operations and crops implies that farms are uniform in the use to which they put it, an assumption that cannot be justified *a priori*.

Also, by looking at the aggregate effects alone, it is not possible to identify the operations where mechanisation is likely to have the maximum impact. And in so far as certain operations tend to be performed by certain

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types of labour, questions relating to which type of labour is likely to be affected can only be answered adequately through disaggregation.[4]

Preoccupation with the aggregate effects, however, is not the only limitation of previous studies. Often inaccuracies in measurement are introduced in one or more of the following ways:

— taking ownership of a technique as a surrogate for use (where hiring of machines is common, this is likely to bias the results);
— attributing to a mechanised technique the effects of other techniques or inputs;
— studying the employment effects without differentiating between different types of labour, i.e. family, permanent and casual labour.

My own study was an attempt to fill some of these gaps in earlier research. In order to highlight the disaggregated employment effects of alternative techniques, I shall be presenting in this article a crop-specific analysis[5] for high-yielding variety (HYV) wheat in the Punjab.[6] In this context three broad but related questions will be addressed:

*(a)* What alternative techniques or combinations of techniques are being used for each operation on the farm plots in the sample studied?
*(b)* Do different techniques vary significantly from one another in their use of labour time for a particular operation?
*(c)* What is the composition (in terms of family, permanent and casual labour units) of the labour used for different operations, with alternative techniques and on farms of different sizes?

The reasons for choosing HYV wheat for the crop-specific analysis are spelt out in the next section.

## Data used

The empirical exercise undertaken here relates to plots belonging to a sample of 240 owner-cultivator farms taken from the principal wheat-growing areas of the Punjab and covering all its districts, for the crop year 1971/72. The data were collected under the "Comprehensive Scheme for Studying the Cost of Cultivation of Principal Crops" by the Punjab Agricultural University (PAU) for the Directorate of Economics and Statistics (DES), New Delhi. The cost-accounting method was used, that is, information was obtained on the basis of day-to-day observation of selected cultivators by a full-time research worker residing in the villages. This method provides much more precise and accurate information than does the often used "recall method" which relies on the memory of the respondent, since it is virtually impossible to recall precisely, at any given point in time, the number of hours or even days spent by different types of labour on various agricultural tasks over the year.

In comparison with the Farm Management Studies (FMS) data (also collected by the PAU for the DES, using the cost accounting method), on which most previous research on mechanisation in the Punjab is based, the Cost of Cultivation data used here have a number of advantages. They have a wider coverage (the FMS data for the Punjab are confined to the Ferozepur district), a larger sample size (the FMS sample contains only 150 farms), and provide more detailed information (the FMS data do not, for instance, include details about the operations for which the machinery is used, and whether it is owned or hired).

The choice of HYV wheat for the crop-specific analysis was determined by two considerations. First, the highest level of mechanisation in the Punjab (and indeed in India) is found in wheat cultivation and the range of observable techniques is therefore greater than with other crops in this region (or even elsewhere);[7] second, this is the main crop grown on the farms in the study area.

## Results and interpretation

### Alternative techniques used, by type of operation

Tractors, tubewells and threshers were found to be the main mechanical aids being used in the Punjab. The level of mechanisation was observed to vary considerably between farm operations[8] (see table 1). At one end of the spectrum came harvesting, which was still being carried out by hand on almost all the plots, and interculture (essentially weeding); at the other end was threshing, which was completely mechanised for 72.5 per cent of the plots and at least partially mechanised (with bullocks supplementing the thresher or tractor) for another 22.4 per cent. Like threshing, irrigation was done largely by modern means—tubewells were used on 86.5 per cent of the plots, either on their own or along with canals or wells; 42 per cent of the tubewells were being run by diesel engines and 58 per cent by electric motors. Ploughing and sowing used both traditional and modern techniques, the bias being towards the former. On the majority of plots the two operations were still being done primarily with the help of bullocks. Even when tractors were used, bullocks were often retained as an insurance against the risk of mechanical breakdown or to make up for the inadequacy of hired tractor services.

Hiring of tractors was in fact fairly common: 42.2 per cent of the plots ploughing with a tractor used a hired one, while 27.9 per cent of the tractor-sowing plots did so. If ownership of tractors had been taken as the criterion for differentiating between tractor-using and bullock-using plots, as in some recent studies,[9] then these tractor-ploughing and tractor-sowing plots would have been misclassified as bullock-using. Machine hiring was also common for threshing. Among the plots whose output was threshed mechanically (with either a tractor or a thresher), 63.7 per cent used an owned machine and the rest a hired one.

It is noteworthy that even on farms owning tractors, their use was largely confined to ploughing, with some limited use in sowing. They were rarely employed to power irrigation pumps and their use in threshing, whether on their own or to provide power to threshers, was not common to all tractor farms either.[10]

## Labour time required with alternative techniques, by type of operation

The labour time required for a given operation was found to differ considerably between different techniques. Table 1 gives the mean use of human, bullock and mechanical energy for each operation and technique in hours per hectare and hours per unit of output, as appropriate.[11] To test the statistical significance of the differences in the mean human labour hours used for each operation with alternative techniques, "t" values were also computed (the results are summarised in a footnote to table 1).

We note from the table that, for both ploughing[12] and sowing, the non-mechanised, exclusively bullock-using plots use substantially more human labour hours per hectare ($L/H$) on average than the partially mechanised bullock + tractor plots, and these in turn use more $L/H$ than the exclusively tractor-using ones. In ploughing the decrease in $L/H$ from exclusively bullock to exclusively tractor plots is as much as 82.4 $L/H$ (or 81.4 per cent), and in sowing it is 23.6 $L/H$ (or 59 per cent). Pair-wise comparisons of the mean $L/H$ used with the three techniques indicates that the differences are significant at the 1 per cent level in all three comparisons relating to ploughing. The displacement of human labour time in this operation closely complements that of bullock-pair time and largely reflects the reduced demand for a driver's services (one man being used to drive one bullock-pair).

In interculture, $L/H$ used with the manual method is significantly higher (at the 1 per cent level) than when bullocks are used. In irrigation, among the five methods of irrigation being used, namely well, canal, tubewell + well, tubewell + canal and tubewell alone, the most $L/H$ is used in well irrigation, followed by tubewell + well. Canal irrigation makes the least use of $L/H$ and tubewell + canal irrigation the second lowest. Exclusively tubewell-irrigated plots fall between the tubewell + well and tubewell + canal categories. All these sources differ significantly (at the 1 per cent level) in their mean use of $L/H$. The results are in keeping with an expected pattern. With canal irrigation no labour is needed for operating the source and a minimum of labour is needed for preparing the field, which is usually left to be flooded. Well and tubewell irrigation, on the other hand, require more labour for preparation of channels, for operating the source and for closer over-all management. Operating a well requires more labour time than operating a tubewell.

For threshing, the mean human labour hours used per unit of output ($L/O$), i.e. per quintal of wheat threshed, were computed. Broadly, three

Table 1. Human, bullock and mechanical energy used in HYV wheat cultivation, by operations and techniques

| Operation and technique | No. of plots (N = 790) | % of plots | Hours per hectare[1] (mean values) | | |
|---|---|---|---|---|---|
| | | | Human labour[2] | Bullock-pairs | Machines |
| *Ploughing:* | | | | | |
| Bullock | 463 | 58.76 | 101.27 | 97.10 | — |
| Bullock + tractor | 229 | 29.06 | 61.28 | 45.16 | 7.60 |
| Tractor | 96 | 12.18 | 18.86 | — | 12.41 |
| Unknown[3] | 2 | — | — | — | — |
| *Sowing:* | | | | | |
| Bullock | 617 | 79.72 | 40.06 | 20.74 | — |
| Bullock + tractor | 44 | 5.68 | 18.48 | 4.55 | 2.33 |
| Tractor | 103 | 13.31 | 16.41 | — | 2.54 |
| Other[4] | 10 | 1.29 | — | — | — |
| Unknown[3] | 16 | — | — | — | — |
| *Interculture:* | | | | | |
| Absent | 154 | 19.49 | — | — | — |
| Manual | 576 | 72.91 | 109.42 | — | — |
| Bullocks | 60 | 7.59 | 67.82 | 13.56 | — |
| *Irrigation:* | | | | | |
| Well | 10 | 1.28 | 241.79 | — | — |
| Canal | 96 | 12.24 | 51.93 | — | — |
| Tubewell[5] + well | 12 | 1.53 | 177.17 | — | 68.42 |
| Tubewell[5] + canal | 105 | 13.39 | 93.30 | — | 49.26 |
| Tubewell[5] | 561 | 71.56 | 140.53 | — | 106.94 |
| Unknown[3] | 6 | — | — | — | — |
| *Harvesting:* | | | | | |
| Manual | 781 | 99.24 | 129.21 | — | — |
| Other[6] | 6 | 0.76 | — | — | — |
| Unknown[3] | 3 | — | — | — | — |
| *Threshing:*[1] | | | | | |
| Bullock | 39 | 5.08 | 7.61 | 1.97 | — |
| Bullock + thresher/ tractor | 172 | 22.43 | 4.84 | 0.46 | 0.54 |
| Thresher/ tractor | 550 | 71.71 | 3.51 | — | 0.63 |
| Other[6] | 6 | 0.78 | — | — | — |
| Unknown[3] | 23 | — | — | — | — |

[1] Hours per quintal (100 kg) of wheat in the case of threshing. [2] Pair-wise comparisons were also made of the mean human labour used with alternative techniques for each operation and the significance of the differences so obtained was tested, using a one-tailed "t" test. It was found that for ploughing, interculture and threshing the differences were significant at the 1 per cent level. For sowing, too, they were significant at the 1 per cent level for all comparisons except that relating to "bullock + tractor" and "tractor", which was insignificant at the 5 per cent level. For irrigation, again, the differences were significant at the 1 per cent level in all cases except those relating to "well" compared with "tubewell + well" (significant at the 5 per cent level) and "tubewell + well" compared with "tubewell" (insignificant at the 5 per cent level). [3] "Unknown" denotes cases where the technique used was not known. These cases have not been included when computing the percentages. [4] Under sowing, "other" includes cases where both sowing and manuring are done together with a seed-cum-fertiliser drill. [5] The tubewell category includes pumpsets. [6] Under harvesting and threshing, "other" includes cases where a combine has been used to perform both operations jointly.

methods of threshing can be distinguished: the traditional one of bullock threshing, the modern one of using a power-operated thresher or tractor, and the intermediate one where part of the output is threshed by bullocks and part by a thresher or a tractor. We note that when threshing is done exclusively by bullocks, *L/O* is significantly greater (at the 1 per cent level) than when a thresher/tractor as well as bullocks are used, and *L/O* with the latter method is, in turn, significantly higher than when a thresher/tractor alone performs the operation.[13]

It is worth noting here that while the technique of cultivation used for an operation is the most important factor affecting the input of labour per hectare, it is not always the sole factor. In the case of seed-bed preparation, in particular, the crop rotation pattern and soil type also tend to be of significance.[14] More intensive ploughing is required after certain crops and on heavier soils. In my sample different zones served as broad surrogates for differences between plots in cropping patterns and soil conditions. The three zones had the following crop rotations: in the *rabi* season (October-April) HYV was the predominant crop on all the plots and in *kharif* (May-September) the principal crops were paddy and maize in Zone I, some combination of groundnuts/paddy/maize/cotton in Zone II, and mainly cotton in Zone III. Cotton usually leaves the most stubble while in groundnut cultivation some soil digging takes place during harvesting itself. Hence, as one might expect, the labour input per hectare in seed-bed preparation for wheat was the greatest in Zone III and the least in Zone II, with Zone I coming in between. Also, not unexpectedly, the differences were found to be larger on bullock-ploughed plots than on tractor plots, since with tractors difficult field conditions do not necessarily require an increase in human effort, either by itself or associated with a larger number of ploughings.

Another variable which was seen to affect the input of human labour per hectare albeit only in some operations such as interculture, was farm size, which was found to be inversely related to labour use in this operation. For seed-bed preparation, however, the labour input varied little with farm size.

## Type of labour affected by mechanisation

Given that mechanisation leads to a decrease in the aggregate use of labour time, an important complementary question is: what kind of labour is affected? Here a distinction between *labour time* effects and the effect on *labourers* is useful. A reduction in requirements of family labour time, for instance, may lead to no particular hardship for the workers (and may in fact constitute a benefit in terms of increased leisure), since they would usually be able to continue subsisting on the farm if no alternative full-time employment were available. Similarly, permanent labourers, even if under-utilised during some parts of the year, may be retained to reduce the risk of

a labour shortage during the peak periods. On the other hand, a reduction in demand for casual labour time would usually mean a displacement of labourers, apart from having an immediate effect on the subsistence earnings of those workers who are hired on an hourly or daily basis. We thus need to break down the total labour time effect by the categories of workers affected.

My results indicate that the type of labour likely to be affected by mechanisation will depend essentially on which agricultural operation is mechanised and on the size of the farm concerned.[15] From table 2 it may be noted that, for every operation, the percentage use of family labour time decreases steadily, almost without exception, as farm size increases. This decrease is accompanied by an increase in the use of either permanent or casual labour time, or both. Ploughing, sowing and irrigation are done largely by either family or permanent labour, with a predominant use of the former on the smaller farms and of the latter on the larger ones. There is relatively little use of casual labour for these operations even on the larger farms. In interculture, harvesting and threshing, on the other hand, there is relatively greater use of casual labour, and the decrease in family labour use with an increase in farm size is accompanied by an increase in the use of both permanent and casual labour. In harvesting, in particular, casual labour is the predominant type in all size groups except the smallest, where family labour continues to be more important.

The observed pattern suggests a task specificity in the use of different types of labour. It also suggests that in operations such as ploughing and in the sowing and irrigation of wheat, given the observed close inverse relationship between family and permanent labour, the latter tends to be a much closer substitute for the former than does casual labour. This is probably because these operations are considered to be more vital than the others and to require greater skill (and/or responsibility), which permanent labour is expected to have acquired.

We now return to the question of the differential effect of mechanisation on various categories of labour. Table 3 shows the change in the number of hours worked (for a given area or unit of output) by different types of labour, broken down by farm operations and farm size. In each case the effect has been measured by comparing labour time on plots using exclusively one technique with those using exclusively the other technique. Plots using some combination of both techniques do not enter into the computations.

We note from the table that, in keeping with our observations so far, the type of labour most affected varies with farm size and operations. In ploughing, on the smallest farms (4 hectares or less) the use of tractors tends to affect mainly the input of family labour time, the decrease in which accounts for over 88 per cent of the reduced requirement of total labour time for ploughing on these farms. As farm size increases the proportion of family labour time displaced decreases while that of

Table 2. Composition of labour time used in HYV wheat cultivation, by operations and farm size (%)

| Operation and type of labour | Farm size (in hectares) | | | | | | |
|---|---|---|---|---|---|---|---|
| | All sizes | 0-4 | 4.1-8 | 8.1-12 | 12.1-16 | 16.1-20 | > 20 |
| *Ploughing* | | | | | | | |
| Family | 64.6 | 87.8 | 67.8 | 54.5 | 36.7 | 64.0 | 42.3 |
| Permanent | 32.1 | 11.6 | 31.1 | 36.0 | 62.4 | 35.9 | 52.1 |
| Casual | 3.3 | 0.6 | 1.1 | 9.5 | 0.9 | 0.1 | 5.6 |
| *Sowing* | | | | | | | |
| Family | 63.3 | 88.2 | 71.5 | 55.4 | 32.6 | 30.2 | 22.3 |
| Permanent | 31.0 | 8.1 | 25.5 | 33.2 | 63.8 | 66.5 | 64.9 |
| Casual | 5.7 | 3.7 | 3.0 | 11.4 | 3.6 | 3.3 | 12.8 |
| *Interculture* | | | | | | | |
| Family | 53.0 | 77.9 | 57.6 | 41.5 | 34.9 | 35.7 | 24.1 |
| Permanent | 24.2 | 6.3 | 24.2 | 27.4 | 42.3 | 34.6 | 38.2 |
| Casual | 22.8 | 15.8 | 18.2 | 31.1 | 22.8 | 29.7 | 37.7 |
| *Irrigation* | | | | | | | |
| Family | 58.8 | 87.1 | 65.6 | 47.0 | 30.9 | 29.6 | 26.2 |
| Permanent | 39.0 | 12.3 | 32.4 | 50.2 | 68.8 | 69.2 | 63.8 |
| Casual | 2.2 | 0.6 | 2.0 | 2.8 | 0.3 | 1.2 | 10.0 |
| *Harvesting* | | | | | | | |
| Family | 39.8 | 70.9 | 40.6 | 27.6 | 20.6 | 30.1 | 12.8 |
| Permanent | 14.3 | 6.5 | 12.0 | 17.8 | 25.0 | 19.5 | 28.3 |
| Casual | 45.9 | 22.6 | 47.4 | 54.6 | 54.4 | 50.4 | 58.9 |
| *Threshing* | | | | | | | |
| Family | 55.3 | 77.5 | 61.3 | 44.7 | 33.6 | 43.3 | 19.2 |
| Permanent | 24.0 | 6.0 | 18.7 | 33.2 | 40.5 | 44.9 | 48.8 |
| Casual | 20.7 | 16.5 | 20.0 | 22.1 | 25.9 | 11.8 | 32.0 |

Table 3. Effect of mechanisation on different types of labour used in HYV wheat cultivation, by operations and farm size[1] (Hours per hectare[2])

| Operation and type of labour | Farm size (in hectares) | | | | | | |
|---|---|---|---|---|---|---|---|
| | All sizes | 0-4 | 4.1-8 | 8.1-12 | 12.1-16 | 16.1-20 | >20 |
| 1. *Tractor ploughing* | −82.4 | −91.5 | −88.9 | −80.3 | −76.6 | −70.5 | −78.6 |
| Family | −59.6 | −81.2 | −59.2 | −50.7 | −31.4 | −26.9 | +1.0 |
| Permanent | −21.3 | −10.4 | −29.2 | −24.0 | −45.2 | −43.3 | −57.7 |
| Casual | −1.5 | — | −0.5 | −5.6 | — | −0.3 | −21.9 |
| 2. *Tractor sowing* | −23.7 | −18.8 | −25.0 | −27.9 | −13.7 | −8.1 | −16.9 |
| Family | −23.2 | −24.1 | −19.2 | −24.8 | −9.5 | −1.2 | −2.3 |
| Permanent | −2.5 | −0.7 | −6.8 | −5.6 | −2.7 | −5.8 | −16.6 |
| Casual | +2.0 | +6.0 | +1.0 | +2.5 | −1.5 | −1.1 | +2.0 |
| 3. *Tubewell irrigation* | +88.6 | +100.8 | +97.0 | +66.8 | +45.5 | +84.6 | +87.3 |
| Family | +46.8 | +82.9 | +56.7 | +22.4 | +13.8 | +2.1 | +6.2 |
| Permanent | +38.7 | +16.8 | +38.7 | +39.9 | +31.2 | +80.1 | +59.2 |
| Casual | +3.1 | +1.1 | +1.6 | +4.5 | +0.5 | +2.4 | +21.9 |
| 4. *Power threshing*[2] | −4.1 | −4.9 | −4.7 | −4.0 | −3.5 | −3.9 | −2.9 |
| Family | −2.3 | −3.9 | −2.9 | −1.7 | −1.2 | −3.2 | −1.6 |
| Permanent | −1.0 | −0.3 | −0.9 | −1.4 | −1.4 | −0.8 | −2.6 |
| Casual | −0.8 | −0.7 | −0.9 | −0.9 | −0.9 | +0.1 | +1.3 |
| **Combined effects** | | | | | | | |
| 1+2 | −106.1 | −110.4 | −113.9 | −108.2 | −90.3 | −78.6 | −95.5 |
| Family | −82.8 | −105.3 | −78.4 | −75.5 | −40.9 | −28.1 | −1.3 |
| Permanent | −23.8 | −11.1 | −35.9 | −29.6 | −47.9 | −49.1 | −74.3 |
| Casual | +0.5 | +6.0 | +0.4 | −3.1 | −1.5 | −1.4 | −19.9 |
| 1+2+3 | −17.5 | −9.6 | −16.9 | −41.4 | −44.8 | +6.0 | −8.2 |
| Family | −36.0 | −22.4 | −21.7 | −53.1 | −27.1 | −26.0 | +4.8 |
| Permanent | +14.9 | +5.7 | +2.8 | +10.2 | −16.7 | +31.0 | −15.0 |
| Casual | +3.6 | +7.1 | +2.0 | +1.5 | −1.0 | +1.0 | +2.0 |

[1] The mechanisation effect has been measured by subtracting the mean labour used with the modern technique from the mean labour used with the traditional technique for the operation and size group concerned. The techniques considered are as follows: for ploughing and sowing, tractors instead of bullocks; for irrigation, tubewells instead of canals; for threshing, thresher/tractor instead of bullocks. [2] Hours per quintal in the case of threshing.

permanent and casual labour time displaced increases.[16] Similarly with sowing, tractors tend primarily to reduce requirements of family labour time on the smaller farms and of permanent labour time on the larger ones, with some slight increase in the use of casual labour time. In irrigation, mechanisation (the use of tubewells instead of canals) leads not to a decrease but to an increase in the use of labour time on farms of all sizes. On the smaller ones the increase is largely in terms of family labour time, and on the larger ones of permanent and, to a lesser extent, of casual labour time. Finally, in threshing, where mechanisation is labour displacing, the displaced labour consists mainly of family and, to a limited extent, of casual labour on the smaller farms, and of family and permanent labour on the larger ones.

So far we have been looking at mechanisation in different farm operations separately. When their combined effects are taken into account it is noted that:

*(a)* On the smaller farms of 12 hectares or less the reduction in labour hours per hectare through the use of a tractor for ploughing and sowing primarily concerns family and also, to a limited extent, permanent labour. The use of a tubewell on these farms increases the use of all labour, but particularly of family labour. Tubewells, in other words, help to offset the labour displacement effect of tractors. The combined effect of a tractor and a tubewell on these farms is to decrease the use of family labour time, though to a lesser extent than if tubewells had not been introduced; and to increase the use of permanent and casual labour time, the increase in the former being less than if tubewells alone had been introduced.

*(b)* On the larger farms of over 12 hectares tractor ploughing and sowing lead primarily to a reduction in the use of permanent labour time and, to a lesser extent, of family and casual labour time. Again, the introduction of a tubewell increases the use of all labour, but this time particularly of permanent labour. The net result of introducing both a tractor and a tubewell on these farms is, however, less clear-cut. Broadly, there tends to be a decrease in the use of family labour time and the negative effect of tractors on permanent labour time is not completely offset in all the larger farm size groups by the positive effect of tubewells.

*(c)* With the addition of a thresher on farms already having a tractor and a tubewell there is a further reduction in the use of family labour time, and any increase in the use of permanent labour time is curtailed. This holds true for farms of all size groups.

### Effect on female labour

I have till now concentrated on categories of labour in terms of employment status (family, permanent and casual). When a further

Table 4. Use of female labour in HYV wheat cultivation, by operations[1]

| Operation | Labour time (in hours) | | | | Female labour time as % of— | |
|---|---|---|---|---|---|---|
| | Total | Female | | | total labour time in operation concerned | female labour time in all operations |
| | | Total | Family | Casual | | |
| Ploughing | 20 547 | — | — | — | — | — |
| Sowing | 2 154 | 403 | 367 | 36 | 18.7 | 5.1 |
| Interculture | 3 383 | 78 | 78 | — | 2.3 | 1.0 |
| Irrigation | 3 779 | 57 | 37 | 20 | 1.5 | 0.7 |
| Harvesting | 43 552 | 6 940 | 396 | 6 544 | 15.9 | 87.8 |
| Threshing | 6 769 | 426 | 424 | 2 | 6.3 | 5.4 |
| **All the above operations** | **80 184** | **7 904** | **1 302** | **6 602** | **9.8** | **100.0**[2] |

[1] The table relates only to the 66 farms using female labour. [2] Of this, female *family* labour accounts for 16.5 per cent and female *casual* labour for 83.5 per cent.

disaggregation by gender is undertaken, it is found that the involvement of women in field activities connected with wheat cultivation is limited. Of the 240 farms in the sample only 66 (27.5 per cent) use any female labour for the crop and even fewer use any women family workers.[17]

Table 4 gives the operation-specific use of female labour time on the 66 farms using at least some female labour (family and/or hired). Women are seen to contribute 9.8 per cent of the total labour used for the specified operations on these farms. Most of this labour—83.5 per cent—is casually hired and the rest is contributed by women family workers, there being no permanent female labourers involved in crop production activities. The two operations in which the contribution of female labour is seen to be of some importance are sowing and harvesting, where it constitutes 18.7 and 15.9 per cent respectively of total labour time. Almost all the female labour in sowing is provided by family workers and almost all of that in harvesting by casually hired women.

Harvesting is seen to account for 87.8 per cent of the total female labour time in HYV wheat cultivation. In so far as wheat harvesting is still largely performed manually, mechanisation associated with this crop is not a threat to women's wage employment as yet. Any introduction of combine harvesters, however, is likely to have a major displacing effect for both female and male casual labour.

## In conclusion

At the beginning of this paper the need to disaggregate the employment effects of mechanisation by specific operations and crops was

emphasised. From the results, it was noted that such a disaggregation assisted in highlighting a number of aspects which would have been obscured in an aggregative analysis. For instance, it helped to bring out the differences between operations such as ploughing and sowing in the labour displacement effect of tractor use. It also helped to separate the divergent effects of different types of mechanisation, such as the negative labour use effect of tractor ploughing and sowing from the positive effect on labour use of mechanising irrigation through tubewells. Most important of all, it helped to trace the differential effect on different types of labour, and hence to identify the contexts in which mechanisation is likely to have the most impact on them. In so far as a differential social weighting needs to be given to the incomes received by different types of labour, e.g. a higher weighting for casual workers (most of whom will usually be landless) than for family workers, this will have implications for the estimation of the social cost of certain mechanised techniques and for decisions about the social desirability of promoting such techniques.

## Notes

[1] I am grateful to Ingrid Palmer and the *Review*'s referee for comments on an earlier draft. The article is based largely on my doctoral dissertation, *Mechanisation in farm operations—choices and their implications: a study based on Punjab* (University of Delhi, Department of Economics, December 1977).

[2] For an analytical review of a number of these studies see Agarwal, op. cit.; and Hans P. Binswanger: *The economics of tractors in South Asia—an analytical review* (New York, Agricultural Development Council; and Hyderabad, International Crops Research Institute for the Semi-Arid Tropics, 1978).

[3] One of the rare (and best known) exceptions to this is the study by Martin Billings and Arjan Singh: "Mechanisation and rural employment, with some implications for rural income distribution", in *Economic and Political Weekly* (Bombay), 27 June 1970. They consider the possible effects of mechanisation separately for each operation. However, their estimates consist of a set of norms evaluated from a variety of data sources and do not relate consistently to any one sample of farms. Hence their study at best provides only a broad idea of possible effects.

[4] This is not to say that the aggregate effects are unimportant. In fact such an analysis is necessary as a *complementary* exercise, since certain effects of mechanisation, as on the farm's cropping intensity (which in turn has a crucial bearing on the total employment-generating capacity of a given piece of land over the year), are not brought out in a crop-specific study. We might say that a disaggregation by operations gives an insight into the crop-specific effects, and the latter along with the cropping intensity effects help us to understand the aggregate implications better.

[5] The fuller study included, in addition, an analysis of the cropping intensity and the aggregate employment effects (see Agarwal, op. cit.).

[6] The analysis is limited to the *direct* impact on employment. Any *indirect* employment generated through mechanisation, such as in the manufacturing and servicing of machinery or in the marketing of any additional output produced, has not been considered. For a discussion on this see R. G. Ridker: "Agricultural mechanization in South Asia", in *Development Digest* (Washington), Jan. 1971; and Raj Krishna, who spells out a methodology for quantifying the indirect effects in "Measurement of direct and indirect employment effects of agricultural growth with technical change", in Edgar O. Edwards (ed.): *Employment and developing nations: report on a Ford Foundation study* (New York, Columbia University Press, 1974).

[7] It is also noteworthy that the level of mechanisation in India, particularly in terms of tractors, is higher in the Punjab than in any other state. In 1972 the Punjab had 42,400 tractors,

or 28.6 per cent of the total in the country. See *Statistical abstract, India, 1975* (New Delhi, Central Statistical Organisation, 1977), p. 58.

[8] Data on labour used in fertiliser application were incomplete; hence this operation has not been included in the analysis.

[9] See, for instance, C. H. Hanumantha Rao: *Technological change and distribution of gains in Indian agriculture* (Delhi, Macmillan Company of India Ltd., 1975); and Prem Vashishtha: *Issues in technological adaptations and agricultural development—an analysis of production functions on Punjab farms*, Ph.D. dissertation (University of Delhi, Department of Economics, April 1975).

[10] Factors contributing to the limited use of tractors for crop production activities include inadequate investment in supplementary tractor equipment, a lack of experience in the early years of tractor use, and poor tractor repair facilities. See, for instance, Bruce Johnston and Peter Kilby: *Agricultural strategies, rural-urban interactions, and the expansion of income opportunities* (Paris, OECD Development Centre, 1973).

[11] To compute the total labour time used for an operation, one hour of female labour was assumed to be equivalent to one hour of male labour, and one hour of child labour to be equivalent to half an hour of adult labour. Most studies take one hour of female labour to be equivalent to only half an hour of male labour, but the available evidence on relative male/female productivity does not justify this assumption *a priori*. See, for example, Bina Agarwal: *Work participation of rural women in the Third World—some data and conceptual biases* (Institute of Development Studies, University of Sussex, 1979; mimeographed).

[12] The labour time indicated for ploughing in fact includes that spent on all activities connected with seed-bed preparation. However, since ploughing is the main activity involved, the operation will be referred to simply as "ploughing".

[13] Combine harvesters were in use on only six plots belonging to two farms in the sample. The number of observations was too small to make a definitive statement on their labour displacement effect.

[14] Inderjit Singh, Richard Day and S. S. Johl in their Punjab-based study also note that the crop rotation and soil conditions are important determinants of the number of ploughings needed for seed-bed preparation for a given crop. See *Field crop technology in the Punjab, India* (Madison, University of Wisconsin, Social Systems Research Institute, 1968).

[15] Among the few studies that have disaggregated the effect of mechanisation by the type of labour affected are: Billings and Singh, op. cit.; Ashok Rudra: "Employment patterns in large farms of Punjab", in *Economic and Political Weekly*, 26 June 1971; and R. K. Sharma: *Economics of tractor versus bullock cultivation (a pilot study in Haryana)* (University of Delhi, Agricultural Economics Research Centre, 1972; mimeographed). Of these and other studies that have looked at the composition of labour used, only Billings and Singh consider the effect by each farm operation. However, even they provide only a limited insight since their inferences are drawn largely from their field observation of the types of labour commonly seen to perform different operations, and not from an actual quantification. Also, their conclusions do not adequately highlight the importance of farm size in determining the type of labour affected.

[16] Billings and Singh (op. cit.) conclude that mechanisation of preparatory tillage primarily displaces family labour and that the effects on casual and permanent labour are slight. My results indicate the importance of taking size effects into account. It can be seen that the Billings and Singh finding holds true only for small farms and that as farm size increases it is not family but permanent and casual labour time which is likely to be reduced.

[17] The low involvement of female family workers may be attributable to prestige reasons, which cause women to withdraw from or opt out of participating in the fields on farms where the family can afford hired help. The women may of course be doing off-field work indirectly related to cultivation, such as preparing meals for farm labourers, particularly during the peak harvest periods when extra hands are often hired and the provision of meals is customary. However, in the absence of information on such off-field work, it is not possible to substantiate or quantify this.

Another point which has a bearing on agricultural female labour in general is that its use tends to be not merely operation-specific but also crop-specific, women being more frequently involved in the cultivation of some crops, such as rice (particularly for transplanting), than of others, such as wheat.