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THE EFFECTS OF FARM MECHANIZATION ON LABOUR UTILIZATION AND ITS SOCIAL IMPLICATIONS

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It is now generally recognized that developing countries should modernize their agriculture if they are to meet their growing demand for food and raw materials. This is because in traditional agriculture productivity is low and the cost of attaining a given production target is relatively high. Thus, the only way to raising agricultural output is to introduce new inputs and technology to the agricultural sector of these countries.

New technology in agriculture can be divided into labour saving (capital using) and land saving technology. The prevalent attitude among policy-makers in developing countries is to consider modernization and labour saving technologies (mechanization) as synonymous. On the other hand, it is argued that mechanization in a labour surplus economy may aggravate the unemployment problem by displacing a large number of labourers in agriculture. Even where the man-land ratio is not very high, seasonal unemployment is present due to undiversified agriculture, a typical situation in most countries with traditional agriculture.

Bose and Clark estimated a negative net social benefit to West Pakistan for tractor mechanization in a situation of labour surplus.[1] Private benefits diverged from social benefits assisted by Government and local conditions that favoured larger farmers and the use of larger tractors.[2] Such policies as no duties on imported tractors, low interest government loans which undervalue the cost of capital goods as well as undervaluing foreign exchange, subsidise this trend.

However, not every type of mechanization leads to the displacement of labour. Aside from its function in enlarging the gross area cultivated, mechanized equipment and, in particular, tractors may be important in raising yields and creating an additional demand for labour under certain conditions. In addition, speeding up the harvest under conditions of labour shortage at the time of harvest can both minimize attrition in yields and brighten the prospects of multiple cropping.

Land saving technology, on the other hand, is neutral to size of farm, raises yield per hectare, absorbs labour and retards the formation of dualism in the economy.[3]

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1. S. R. Bose and E. H. Clark, "Some Basic Considerations on Agricultural Mechanization n West Pakistan," *The Pakistan Development Review*, Vol. IX, No. 3. Autumn, 1969, pp. 273-308.

2. B. F. Johnston and P. Kilby: Agricultural Strategy and Industrial Growth—A Report on Visits to Taiwan, India and West Pakistan, August-September, 1969.

3. H. Kaneda and W. F. Owen, "The Double Development Squeeze on Agriculture," *The American Economic Review*, Vol. LI, No. 1, March, 1966, pp. 43-70.

Obviously, not all these arguments can be generalised. In certain circumstances under special constraints and objectives some degree of farm mechanization may be necessary or two types of technologies may be complementary. In some cases mechanization may be essential to release the needed labour for the industrial sector, when this sector is growing rapdily.[4]

This paper examines the problems of labour utilization in the three agricultural regions of Fars Province in the south central of Iran. Specifically, the study is concerned with the impact of farm mechanization on labour utilization in the rural areas of Marvdasht Plain. The analysis considers wheat and barley, two major enterprises in the region, and the technologies under investigation are tractor and combine harvester.

Towards this end, a brief description of the area is presented first. The number of available manpower in the region, labour requirements of wheat and barley under different degrees of mechanization, other agricultural enterprises existing in the region and their requirements for labour are then determined. These are needed to estimate the degree of labour utilization in the selected regions. Finally, a regression and budget analysis are used to estimate the number of labour hours displaced by selected technologies and the desirability of using machinery power in place of labour.

The Region

The region is located in south central of Iran comprising 178 villages, about 128 of which are within the Darius Irrigation Project. The project supplying water to 66 villages in the region extends from a point some 30 kilometers from Shiraz the capital city of Fars province to the upper end of the reservoir, some 100 kilometers north and west of Shiraz. With hot temperate climate, the region gets an average annual rainfall of approximately 250 millimeters.

The total irrigated land in the region is about 162,900 hectares of which approximately 51.5 per cent is cultivated each year and the rest is left fallow. In general the lands are heavily textured clay loams and clay well suited to irrigated farming. The land surface is, generally of uniform with gradual slope to the south-east. Except in areas near the villages, undulations are not serious.

Prevalent crops in the region are wheat and barley, sugar beets, alfalfa, cotton and sunflowers.[5] The region has a population of approximately 83,000 with a labour force of about 33,040 man-year.

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4. Y. S. Brenner: Agriculture and the Economic Development of Low Income Countries, Mouton, the Hague, Paris, 1971, pp. 50-54.

5. Of the total farm land actually cultivated each year about 83 per cent is in small grains (66 per cent wheat, 16.5 per cent barley and 1.1 per cent rice) and the rest is in summer crops and alfalfa.

Most farmers in the region still use traditional farming techniques. The use of tractor for ploughing and combine for harvesting began on on average about 22 and 16 years prior to this study, in 1950 and 1956 respectively. Ploughing in most units studied are carried out by hired tractors : seed-bed preparation and sowing in most villages by hand and in few villages by machine, in some farms wheat and barley are harvested by combine. The small farmers, however, harvest their crops by hand and thresh by tractors. Sugar beets and other crops are mainly non-mechanized.

The region has been facing water shortage for many years. Darius Dam provides regulated and timely water to some of the villages starting from the year 1973. Most farm units are small and uneconomic. The villages are not scattered and their distances from the main road except some do not exceed few kilometers. Significant features observed throughout the villages are : excess amount of human labour per unit produced and erratic use of the tractor power available.

Study Procedure

Since a detailed study of all agricultural regions in the province was not possible, three regions in the Marvdasht plain were selected. They are Marvdasht, Ramjerd and Bayza. This choice was made for the following reasons: (1) about half of the farms are located within the Darius Irrigation Project in which mechanization is expected to proceed faster than other regions in the province; (2) in a number of villages mechanized and non-mechanized farm are operating side by side; and (3) natural conditions are mainly homogeneous throughout the area.

Due to lack of time-series data (showing the change of technology over time in the region), the analysis was based on cross-sectional data obtained from a randomely selected sample of 30 villages (approximately 20 per cent of the total villages in the region.) Input-output, costs, returns and other data were obtained from 20 per cent of the farmers selected at random in each village. To check for the accuracy of data a number of agricultural experts were consulted and in many cases direct observations were made of actual farming operations. In addition, a number of respondents were selected from among the well informed villagers (Kadkhoda and head Boneh). These respondents no doubt gave more accurate information. To determine the size of population and labour force in the region about 50 per cent of the households were questioned in each village. The sample also includes four mechanized units in the region.

Supply of Labour

The number of workers available (the labour force) in the region was computed by (*a*) converting all women-days and child-days into man-equivalent days by assigning a ratio of 2 child-days = 1.25 woman-day

= 1 man-equivalent day; and (*b*) adding all men-days and man-equivalent days together.

Annual labour requirements : The demand for human labour for wheat and barley production was determined on the basis of (*a*) annual wheat and barley hectareage and (*b*) physical inputs of labour (labour requirements) per hectare.

It is important to keep in mind that various cropping activities will be affected differently by technical change. Broadly speaking, the production of a crop requires four activities : seed-bed preparation and sowing, irrigation interculture and harvest. The sample included three different types of farming :

(1) The small farms in which only part of seed-bed preparation was carried out by hired machinery and the rest of farming operations by hand. (2) Large farms owned by former landlords in which seed-bed preparation and harvest of wheat and barley were carried out by owned machinery and the rest of operations by hired labour. (3) Large private farms and corporate farm units in which only irrigation is carried out manually. Harvesting and threshing are more sensitive to changes in technology; and the use of the combine harvester is expected to replace a large number of seasonal labourers; mechanization of other farming operations has less impact upon hired labour and more upon family labour.

Input-output data, gross and net returns per hectare, and labour and machinery requirements per hectare in each situation were determined. Then these data for total wheat and barley hectareage were estimated.

It is important to determine the degree of utilization of labour, if labour is under-utilized the area under cultivation can be expanded with zero opportunity cost. For this purpose, other enterprises and their requirements for labour were determined using the procedure indicated for wheat and barley. Likewise, the percentage of employment provided by off-farm jobs was estimated. Labour requirements per hectare in the three above cases were split up among the months according to the timing for performing various crop operations. Total and monthly labour requirements for the region were then determined by multiplying the man-hours per hectare times the number of hectares under each crop and adding them up. Based upon the best information from the farmers, experts, and our own observations, estimates were made of the impact of the studied technologies (tractor and combine harvester) upon labour utilization over affected hectareage.

To determine the magnitude of labour hours displaced by selected technologies a simple regression analysis of polynomial form was employed using tractor hour used for seed-bed preparation and combine hours used for har-

vesting as independent variables and the number of labour hours per hectare required to do the same jobs as dependent variable.

It is useful to determine the relative importance of major factors determining labour utilization in the region. For this purpose, a multiple regression analysis was employed using actual labour hours utilized for seed-bed preparation, cultural practices, and harvesting as dependent variable and machinery used for seed-bed preparation, sowing and harvesting, percentage of land allocated to other crops, and yield per hectare of wheat as independent variables.

Finally, a budget comparison of three farming situations was made to determine the desirability of using machinery power in place of labour and its welfare effects. They were mechanized, semi-mechanized and non-mechanized farms.

The Results

Of the gross area surveyed, the land-man ratio was about 4.93 hectares per adult farmer and the average cropped land per adult farmer was approximately 2.54 hectares. This shows that the average farm size in the region in terms of land area is small and uneconomic. The total labour force in the region is estimated at about 33,040 man-year. Approximately, 10 per cent of the available labour force is engaged on off-farm jobs which include part-time seasonal work at Marvdasht sugar and fertilizer factories, and construction activities. Thus, the supply of labour for farming and related enterprises in the region (*i.e.*, carpet weaving, sheep raising, shopkeeping, etc.) is about 29,730 persons.

Assuming there are 200 working days per year and a normal working day of 12 hours per day, the number of persons productively employed in farming and other enterprises is 10,600 persons. Thus, approximately 64 per cent of persons of working age are under-employed.

It is useful to determine the average under-employment in various months. Table I shows the labour requirements for farming and other enterprises in the region. As indicated, even at the peak of agricultural activities (months of July, October and November) the labour supply exceeds the labour requirements for farming.

To compare the labour requirements and its distribution over agricultural seasons under different degrees of mechanization, three situations were considered : (1) Mechanized farms (two farm corporations and one large private farm existing in the region). Here, the cropping system and the degree of mechanization, in the region is assumed to be similar to these three farms. (2) Existing situation in the region; and (3) the prevailing degree

TABLE I—LABOUR REQUIREMENTS IN THE REGION (BY MONTH)

	April	May	June	July	August	September	October	November	December	January	February	March
Man-hours ..	1,019,707	2,086,490	2,516,897	5,436,554	1,562,456	1,582,080	2,599,631	3,486,492	1,805,696	592,800	592,800	2,156,383
Man-month ..	5,098.5	10,432.4	12,584.4	27,182.7	7,812.7	7,910	12,998	17,432	9,028.4	2,964	2,964	10,782

Total labour requirements 25,438,079 man-hours = 10,600 man-year. Total labour supply 33,040 man-year.

TABLE II—LABOUR REQUIREMENTS BY MONTH ASSUMING A DEGREE OF MECHANIZATION SIMILAR TO ARYA MEHR FARM CORPORATION

Man-hours ..	1,633,350	3,189,712	2,613,000	2,797,275	1,267,500	1,335,750	1,927,575	1,955,712	2,174,250	624,000	624,000	2,809,462
Man-month ..	8.313.5	15,994.5	13,065	13,981.5	6,337.5	6,675.5	9,633	14,774.5	10,868	3,120	3,120	14,046.5

Total labour requirements 23,981,587 man-hours = 9,992 man-year.

TABLE III—LABOUR REQUIREMENTS BY MONTH ASSUMING A DEGREE OF MECHANIZATION SIMILAR TO DARIUS FARM CORPORATION

	April	May	June	July	August	September	October	November	December	January	February	March
Man-hours ..	1,083,712	2,885,220	1,834,586	1,734,642	1,137,942	1,027,728	1,670,584	1,450,507	2,294,662	508,950	508,950	2,515,350
Man-month ..	5,414.5	14,423.5	9,171.5	8,671	5,687.5	5,135	8,352.5	7,247.5	11,472.5	2,541.5	2,541.5	12,571

Total labour requirements 18,652,842 man-hours = 7,772 man-year.

TABLE IV—LABOUR REQUIREMENTS BY MONTH ASSUMING A DEGREE OF MECHANIZATION SIMILAR TO A PRIVATE MECHANIZED FARM IN THE REGION

	April	May	June	July	August	September	October	November	December	January	February	March
Man-hours ..	481,786	3,396,081	4,260,113	4,090,450	2,823,418	1,595,477	1,640,201	1,436,292	1,905,384	145,080	145,080	1,812,291
Man-month ..	2,405	16,978	21,300.5	20,449	14,111.5	7,975.5	8,200.4	7,181.8	9,522.5	725.4	725.4	9,061

Total labour requirements 23,731,622 man-hours = 9,888 man-year.

TABLE V—LABOUR REQUIREMENTS BY MONTH ASSUMING A DEGREE OF MECHANIZATION SIMILAR TO SMALL FARMERS IN THE REGION

Man-hours ..	1,019,707	2,086,487	2,516,897	9,920,495	1,562,458	1,582,080	3,295,082	3,495,082	195,559	592,800	592,800	2,156,381
Man-month ..	5,096	10,432.5	12,584	49,595	7,813	7,910.5	16,471	17,472	9,776	2,964	2,964	10,783.5

Total labour requirements 30,775,966 man-hours = 12,823.3 man-year.

* The assumption relates only to wheat and barley.

of mechanization is assumed to be similar to that of the small farms in the region. That is, only ploughing and discing are done by tractor and the rest of farming operations by hand. Tables II to V and Figure 1 show the total labour requirements and its distribution over months under the three situations. Only in the third situation the labour requirements in the peak period (harvesting season) would exceed the labour supply (see Table V).

However, even in this situation, the total annual labour requirements is less than the labour supply. A comparison of the three situations also indicates that the distribution of monthly labour requirements of crops and other enterprises in the region is more even in the mechanized than in the non-mechanized farms (see Figure 1).

One of the advantages of the introduction of tractor and combine harvester in the region has been the reduction of labour requirements and an increase in labour efficiency. It must be noted, however, that the farm labour force in the region consists mainly of the family's unpaid labour. Since no alternative and remunerative employment is available in the region, it seems that no gain can be realised by reducing the labour requirements of current farm operations. Thus, it is the increase in net farm income, and not the reduction of labour requirements and cost that should be the criterion for making decision. Using budgeting technique, the net income of wheat was determined in the three farming situations : mechanized, semi-mechanized and non-mechanized (small) farms. The results are shown in Table VI.

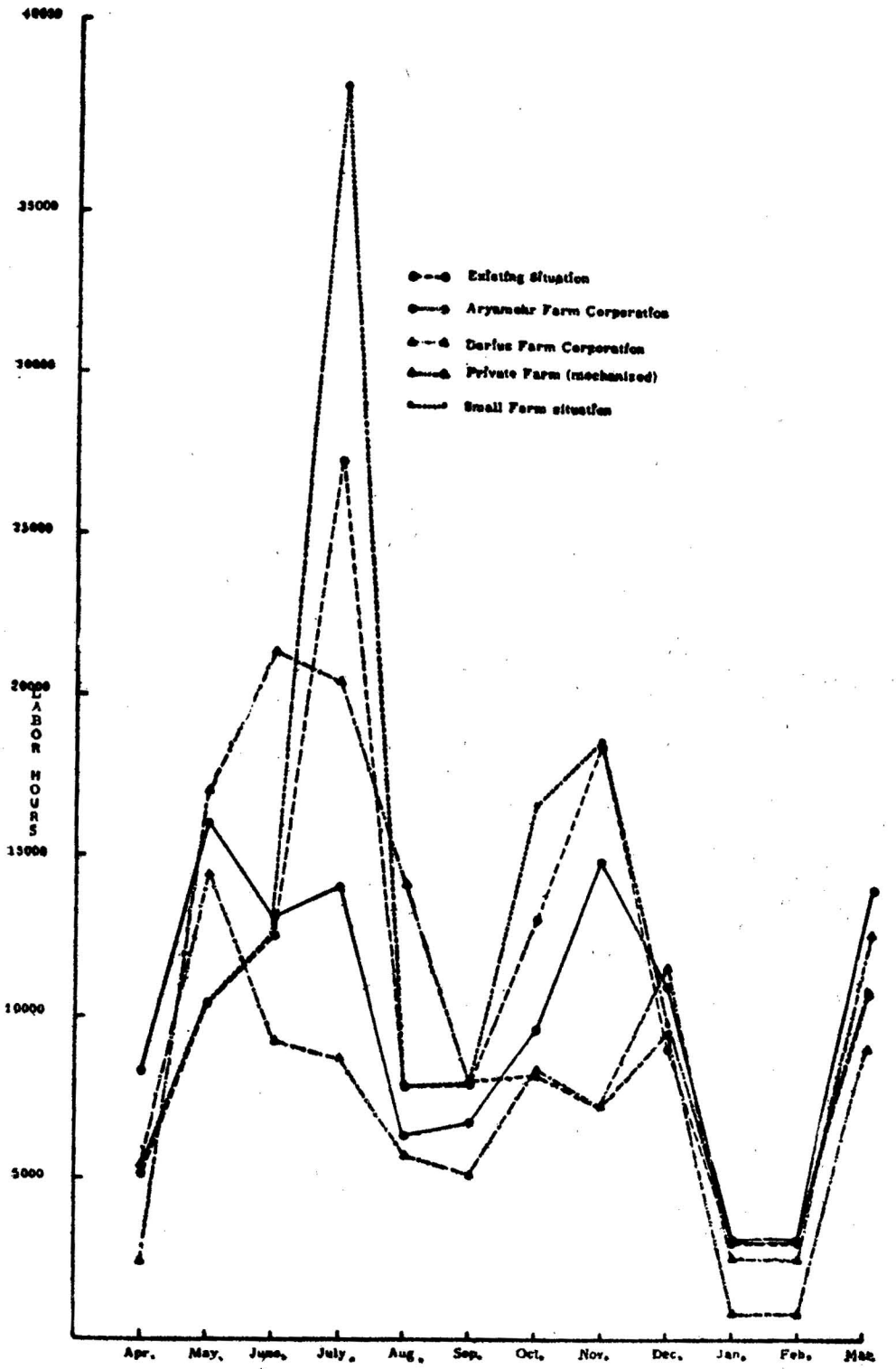
TABLE VI—COMPARISON OF LABOUR REQUIREMENTS, GROSS AND NET INCOME PER HECTARE OF WHEAT IN MECHANIZED, SEMI-MECHANIZED AND NON-MECHANIZED FARMS

Level of mechanization	Labour requirements (hours)	Gross income (Rials)	Cost of production (Rials)	Net income (Rials)
Mechanized	71	15,000	5,291	9,709
Semi-mechanized	95	11,250	5,471	5,779
Non-mechanized*	202	11,250	4,217	7,033

* It should be noted that farmers in mechanized and semi-mechanized farms have to hire the needed labour, while the small farmers use family labour. In the latter case, the cost of labour should not be deducted from the gross income.

As indicated, the net farm income in the case of mechanized wheat is higher than in both the semi-and non-mechanized wheat. However, the non-mechanized wheat (small farmer) appears to be in a more favourable economic position than the semi-mechanized one.

Full mechanization of wheat production results in displacement of nearly 131 hours of labour per hectare. Assuming a wage rate of 10 rials per hour, the mechanized farms can compensate the displaced labour and still be economically better off than the semi-and non-mechanized farms.


Existing situation
Aryamehr Farm Corporation
Darius Farm Corporation
Private Farm (mechanised)
Small Farm situation
LABOR HOURS
35000
25000
20000
15000
10000
5000
Apr.
May.
June.
July.
Aug.
Sep.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.

Under conditions prevailing in the region a successful farm mechanization programme should :

1. Reduce labour requirements in the peak season (harvest period of wheat and barley). This has been achieved to some extent through the introduction of a number of combine harvesters (72) on the large wheat farms. Using combine harvesters on the small farms in addition to technical difficulties would displace a large number of labourers in the region (discussed later). When (as in the year 1972) wheat hectareage is expanded due to increased water or rainfall, the harvesting period has to be extended because of the shortage of skilled labour in harvest season. This results in attrition in yields. Speeding up the harvest under such conditions can both minimize attrition in yields and brighten the prospects of multiple croppings.

2. Provide labour employment during the slack season. As is shown in the above tables, the use of tractor and combine harvesters not only does not provide employment, but reduces labour requirements in the slack season as well as total annual labour requirements.

3. Make it possible to enlarge the farm business by introducing new enterprises and intensifying cultivation such as fertilization and spraying. This result has been obtained to some extent through the introduction of crops such as sunflowers, opium, more summer crops and intensification of cultivation in the case of the three mechanized farms. However, our observation indicates that the shortage of water and lack of know-how on the part of the farmers in the region are the two major factors limiting such diversification and intensification.[6]

4. Make farm work easier, thus inducing the younger generation to remain on the farms. This aim is expected to be attained as were expressed by most farmers in the region.

The study indicates that, while small grains comprise over 80 per cent of the crop hectareage each year the percentage of employment (labour requirements) created by summer crops and other enterprises in the region is larger than that created by small grains. The percentages of labour requirements and hectareage for various enterprises and activities are given below :

Enterprise	Percentage of hectareage	Per cent of labour requirement
Wheat and barley	82.4	32
Sugar beets	8.3	24
Other crops and orchards	9.3	17
Other activities	—	27

In fact our observations and interview did not indicate any relation between fallow land for instance and the extent of mechanization, while most respondents mentioned the shortage of water as a major factor affecting the amount of land cropped each year.

This indicates that diversification of farming enterprises is essential if the percentage of under-employed is to be reduced.

The result of regression analysis showed that the use of tractor for seed-bed preparation and sowing replaces between 35 to 40 hours of labour per hectare,[7] while the combine harvester on an average replaces between 156 to 176 hours of labour per hectare of wheat and barley. The estimating equations are: $\hat{y} = 25.67 - 8.43x + 1.19x^2$ and $\hat{y} = 62.6 + 60.64x - 6.84x^2$ relating tractor and combine hours used per hectare respectively and man-hours of labour required to do the same type of job.[8]

The correlation coefficient and coefficient of determination in the case of tractor were 0.60 and 0.37 respectively and in the case of combine harvesting were 0.34 and 0.12 respectively. They indicate that only about 37 per cent of variation of labour utilization in the case of seed-bed preparation and 12 per cent of variation in the case of harvesting are explained by the use of tractor and combine harvester respectively. Other factors affecting the use of labour per hectare of wheat and barley include kind of soil, labour efficiency, amount of yield per hectare, etc.

A multiple regression analysis was run using labour hours utilized for seed-bed preparation, cultural practices and harvesting as dependent variable and machinery hours used for seed-bed preparation, sowing and harvesting, percentage of land allocated to crops other than wheat and yield per hectare of wheat as independent variables. The correlation coefficient between labour and machinery use per hectare given the amount of land allocated to other crops and yield per hectare of wheat was 0.55. The correlation coefficient between labour utilized per hectare and the percentage of land allocated to other crops given the other two independent variables was 0.95 and that between labour utilized and yield of wheat per hecatre was 0.263. This shows that the amount of labour requirement per hecatre is more related to the percentage of land allocated to crops such as sugar beets and other summer crops than the degree of mechanization and yield of wheat. The coefficient of multiple determination (R^2 1.234) was 0.933 indicating that the three independent variables explain almost all of the variation in labour utilization per hectare in the region studied.

Conclusions and Implications

The agricultural situation in the region studied is characterized by small size of farm, undiversified farming activities and largely under-employed labour. These are common characteristics of many other regions of Iran and most developing countries. Thus, the applicability of the findings can be extended to other areas with similar conditions.

7. That is, ploughing, discing, bordering, levelling and sowing.
8. Both b_1 and b_2 are significant at 0.25.

This study shows that even at the peak of agricultural activities labour supply exceeds labour requirements. The comparison of labour requirements and its distribution under different levels of mechanization indicates that mechanization reduces total labour requirements considerably. However, monthly labour requirements are more even in the mechanized than in the non-mechanized farms. The analysis indicates that full mechanization of wheat production results in the displacement of nearly 131 hours of labour per hectare. In terms of welfare economics, when some people suffer financially as a result of a change compensation is necessary. If the returns of the new technology are not sufficient to pay the cost of change, including the social cost of transformation, the change cannot be considered socially desirable.

It appears that mechanization of wheat production in the region would pass the compensation test if compensation were paid. Since ordinarily no compensation would be paid it may be better to use labour intensive techniques.

Because of low opportunity costs to farmers' time, the net benefit from using tractor or harvester is expected to be low. Should alternative employment opportunity encourage movement of farm labour into nearby town and Shiraz, this net benefit could be expected to rise rapidly, in turn encouraging further demand for mechanized power.

In conclusion, mechanization should proceed gradually; it should be accompanied by diversification of agriculture and improved irrigation. Improved irrigation would probably lead to more intensive methods of crop cultivation and increased demand for labour. The indirect effects from providing more irrigation water are generally associated with double cropping encouraged by better water availability. Since labour requirements rise, mechanization in this case reduces labour demand at peak periods.

Finally, if complete mechanization of major labour using farm practices were to become a fact, the availability of non-farm jobs would have to keep pace with the increasing labour force.