



**AgEcon** SEARCH  
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

[aesearch@umn.edu](mailto:aesearch@umn.edu)

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

*K. William Easter*

*For Restricted Circulation  
to Seminar Participants only*

**BACKGROUND PAPERS FOR DISCUSSION**  
**AT**  
**THE INTERNATIONAL SEMINAR**  
**ON**  
**“COMPARATIVE EXPERIENCE OF AGRICULTURAL  
DEVELOPMENT IN DEVELOPING COUNTRIES  
SINCE WORLD WAR II”**

**NEW DELHI**

**25th, 26th, 27th and 28th OCTOBER. 1971**

**THE INDIAN SOCIETY OF AGRICULTURAL ECONOMICS**  
46-48, Esplanade Mansions, Mahatma Gandhi Road, Fort,  
BOMBAY-I.

THE EFFECT OF TECHNOLOGY ON FARM EMPLOYMENT  
IN INDIA

Martin H. Billings and Arjan Singh\*

This study attempts to infer the influence of a group of associated technical changes in farm production upon the employment of agricultural labor over the period 1960-84 in the Indian states of Punjab (including the area now split off into the state of Haryana) and Maharashtra. The former represents the northern wheat-growing irrigated region and the latter essentially a non-irrigated millet area. The economic structure of agriculture in the two states is widely different; these two different situations are met with in extensive areas of northern and western India. The physical projection model developed in this study is based on our estimates as to the trends in farm working population, cropping patterns, rate of adoption of technological innovations and imputed rate of labor-machine displacement. The model makes use of a rather wide variety of data, some of which reflect local peculiarities in collection and interpretation. These

-----  
\* Development Digest, Vol. IX, No. 1, January 1971.

Excerpted from a paper prepared for a conference "Employment and Unemployment in Near Eastern and South Asian Countries," sponsored by the Government of Nepal and U.S. AID, Kathmandu, Nepal, 6-9 July, 1970.

factors may cause lack of precision, but we do not feel this will affect our conclusions. Our objective is to indicate directions of change; we are interested in relative levels, not in absolutes.

#### Brief Description of the Areas

Punjab, one of the leading agricultural areas in India, is mainly a flat alluvial plain with deep, fertile and highly productive soils. Although rainfall is not high, the state is well served by snowfed rivers and perennial canals, and has easily tappable sub-soil water for irrigation. About two thirds of the cropped area is devoted to foodgrain crops, the most important of which is wheat, accounting for as much area as all other foodgrains. Cattle feed and miscellaneous crops account for another 20 per cent. Among the non-foods, more important crops are cotton (6 per cent) and sugarcane, rape and mustard, and groundnuts each nearly 3 per cent. The staple diet of the people is wheat, supplemented with maize in central districts, rice in hilly areas, and millets and gram in the southern parts of the state. In 1961 Punjab had a total population of about 20 million persons of which some 20 per cent lived in urban areas. About 35 per cent of the population is in the work force, of which 63.4 per cent is engaged in agriculture. Agricultural laborers constituted 12 per cent of the total farm force in 1961 as compared with 17 per cent in 1951; their number is showing sharp decline, particularly of women workers whose proportion among agricultural laborers fell from about 33 per cent in 1951 to 11 per cent in 1961.

Punjab is a land of peasant proprietors; 52 per cent of the cultivators work entirely on their own lands, another 34 per cent augment their own holdings with rented land and only 14 per cent of the households are purely tenants. An average operational holding is about 12 acres; nearly 60 per cent of the cultivating households operate farms larger than 7.5 acres and only 12 per cent operate farms smaller than 2.5 acres. The process of consolidation of scattered and fragmented small fields into larger units has progressed in the state to cover practically all of the farmed land. This feature is of special significance in the Punjab agriculture, as it has given a strong impetus to the extension of irrigated area, land improvement and introduction of new technology. Industrial units in the state are generally small, dispersed and agro-based. The state is well served by roads and railways.

Since 1965 the area under HYV--the new high-yielding varieties of seeds--has sharply risen, in several districts exceeding planned targets. Wheat yields have doubled in the past 5 years, causing farm labor to be much more in demand than before. Farmers are responding to labor shortages and higher wage rates by substituting capital-intensive technology in critical activities, either where they are heavily reliant upon non-family labor or where yield-increasing opportunities are dramatic--notably mechanized water pumping. In 1969 there were about 142,000 diesel and electric pumpsets, 100,000 wheat threshers and 22,349 tractors in Punjab. These figures represent an increase of 11 times in pumpsets and five times in tractors over the past 13 years. Wheat threshers have appeared only

recently; in 1964, their number was estimated to be about 5,000.

Maharashtra is largely an undulating plateau with a number of rivers and valleys and a considerable variety in climate, rainfall, soil fertility and topography. Black soils predominate shading into red soils in the southern parts; both of these soils have poor depth and low level of fertility. On a vast tract, their productive capacity has progressively deteriorated as a result of unchecked erosion. Rainfall is low and highly variable. There are limited layers of aquifers in the sub-surface; irrigation has **not** developed to a degree which could significantly mitigate the natural soil and climatic disadvantages, in fact only 8 per cent of the cropped area is irrigated. Consequently the crop pattern is dominated by jowar-bajra and such other low-yielding and low-value crops. Of the 19 million cropped hectares, nearly 33 per cent is under jowar, 10 per cent under bajra and 12 per cent under pulses, all of which have rather lower productive potential than wheat and rice. Rice is the main crop in the wet coastal area. Commercial crops are mostly cotton (14 per cent) and groundnuts (10 per cent); where perennial irrigation is available sugarcane is grown, but its area is less than one per cent of the cropped acreage. The multiple cropped area is only 8 per cent of the total cultivated.

In 1961/62 there were 3.6 million operational holdings in the state covering an area of over 40 million acres. The average farm size works out to about 11.5 acres; however, 41.6 per cent of holdings are in units of less than 5 acres and operate only

8.5 per cent of the agricultural land. At the other extreme are farms of 50 acres and above, which account for 8.9 per cent of the holdings but cultivate 36.8 per cent of the area. As per 1961 census, Maharashtra had a population of nearly 39.5 millions, 28 per cent of which was urban. Cultivators and agricultural laborers account for 46.1 per cent and 23.8 per cent respectively of the total workers in the state. The participation rate of women workers is very high, being about 46 per cent among cultivators and 53 per cent in agricultural labor. The proportion of agricultural laborers to total farm workers is 34 per cent, which is nearly three times that of Punjab. Industrially Maharashtra is the most advanced state of India, but the concentration of industries is mainly in the Bombay-Poona region and a few other pockets. The rest of the state is predominantly agricultural, with poor land and meagre, unreliable rainfall. Notwithstanding a relatively high degree of overall urbanization and opportunities in non-agricultural employment, the proportion of working force engaged in agriculture is high--about two thirds.

Not much success has been achieved in Maharashtra in introducing hybrid varieties of crops. The area under HYV of jowar and bajra was less than 10 per cent in 1968/69. More than half of the maize area was under hybrid varieties, but this crop is not of much importance in the state and is consumed by the rural population only as a last resort when jowar and bajra are scarce. HYV of paddy are grown in irrigated areas, but cultivators in this state are accustomed to a protective irrigation system, using irrigation water only in the event of failure of rains. Tanks and seasonal rivers mostly supply

water when rainfall is adequate and thus, unlike Punjab, this source of irrigation water is mostly non-perennial; this results in difficulty in using the intermittent assured irrigation which is essential for the successful growing of HYV. Nevertheless crop patterns and yields on rainfed lands could be improved substantially beyond the present level by soil conservation and scientific dry-farming techniques. In 1968/69 the state had 4,500 tractors, 300 power tillers, 4,500 power threshers and 247,000 diesel and electric pumpsets.

#### Data and Method

The measurement of the potential impact of important technological changes on farm employment was done by using a simple physical projection model. The projections for human population are based on estimates of the Planning Commission. From the total population, the labor force projections for the two states were made by assuming rates of increase or decrease in the 1961 Census participation rates by sex and broad age-groups. The farm labor force was determined as a residual from the total work force after estimating the rate of growth of non-farm employment, taking into account past trends and future programs of state non-farm development. Given the total strength of agricultural workers, the share of energy supply used for crop production was calculated after an allowance for time devoted by farm workers to other works, and time lost due to bad weather and sickness.

The requirement of human energy for crop production was determined on the basis of : a) expected cropping pattern over the projected years; and b) physical



inputs of labor. The projection of the cropping pattern involved the estimation of land-use pattern by extrapolating past trends in total arable land broken up into two classes, irrigated and unirrigated, the former having been worked out from the projections by the Planning Commission and state plans. The projected cropped area for future years was allocated to different crops on the basis of percentages of each crop to total area as arrived at by fitting a straight line trend to the data for the period 1950/51 to 1967/68 and determining the limits of variation and optimal cropping pattern by using modified linear programming. Farm management and cost of production studies in the two states were used to estimate the per-acre labor requirements of crops for various agricultural operations. These figures were split up among the months according to the timing for performing various crop operations. The energy requirements of different crops and the total monthly requirements for the state were then worked out by multiplying the man-days per acre times the numbers of acres under various crops and then adding them up.

In working out the proportion of area under HYV and the area irrigated by different sources (pumpsets, canals, etc.), we made use of the projections of the Planning Commission and our own estimates of the area under different crops. For tractors, their number and area likely to be covered by the end of study period were determined, taking into account the likely supply and demand position in future, as estimated by various governmental and other agencies, horsepower of the tractor units, present trends in their use and the pattern of farm operational holdings in the two states. A more

or less similar procedure was followed for other mechanical devices, but in these cases we depended largely upon the estimates of experts close to the subject and our own observations, especially for items which have just appeared on the scene. Finally, the labor-machine displacement was estimated and its impact on human labor demand was calculated, mainly based on studies carried out in the two states.

### Impact of Studied Technologies

Punjab. Seven technological changes have been considered for this state: HYV (assuming use of fertilizer), pumpsets, wheat threshers, tractors, cane crushers, corn shellers and reapers. None of these represents a sharp break from trends presently visible. HYV demand better irrigation facilities, which means intensive mechanized irrigation and later, mechanized threshing and harvesting. The HYV also demand faster seedbed preparation to gain full benefit from their shorter duration, and multiple cropping. Thus, the HYV are the thin end of the wedge which will very likely lead to the progressive mechanization of agriculture, although their initial effect is labor intensive.

The HYV with fertilizers are highly divisible and are a technology open to any farmers on rain-assured or irrigable acreage. Mechanical wheat threshers introduced recently are being used in the state very extensively; these are produced locally within a wide range of capacity and price. Their economies are so clear (about 4-5 times as fast as the traditional system) that it is a question of only a few years

before almost all wheat will be so processed. Since these machines are available in different sizes to suit farmers of different scales, and custom service in threshing has become quite common in the state, this mechanical innovation could be regarded as neutral to scale. Extra yields of HYV of wheat have caused April to be a difficult month for harvesting. A market for rapid mechanical reaping has come into existence rather suddenly with the change in varieties, and some machines have already come into the market. A really suitable machine is yet to be developed, but by the later part of the decade there is reason to believe that such equipment will become commonly available and make an impact on production costs and the demand for labor. Though less neutral to scale than threshers, as the machine becomes common custom work will surely spread and its effect will be widely felt.

A tractor is a costly machine. Its supply is very much subject to public policy and its effect upon farmers and labor is conditioned by rather a wide set of policy and structural variables. Tractors in Punjab are owned largely by big farmers and by some medium farmers holding 15 to 30 acres; they use the tractors mostly for themselves. Several factors will condition the amount of time a tractor owner will be willing to rent out his machine: the size of his own farm, the risk of wear from extra use in an area where service is a real problem, and his ability and readiness to make the necessary business arrangements. Some service, both plowing and transport, is being supplied at present, and more service is likely to develop with increase in tractor numbers, but the extension of custom service

Table 1 : Estimated Extent of Technological Changes in Agriculture from 1968/69 to 1983/84

<u>Item</u>	<u>Punjab</u>		<u>Maharashtra</u>	
	<u>1968/69</u>	<u>1983/84</u>	<u>1968/69</u>	<u>1983/84</u>
<u>I. High-yielding varieties</u>				
Percentages of area under crops where HYV introduced:				
i) wheat	50 <sup>a/</sup>	95 <sup>a/</sup>	7	37
ii) paddy	20 <sup>a/</sup>	80 <sup>a/</sup>	9	60
iii) hybrid maize	15 <sup>a/</sup>	60 <sup>a/</sup>	50	90
iv) hybrid bajra	6 <sup>a/</sup>	60 <sup>a/</sup>	12	60
v) hybrid jowar	--	--	9	30
<u>II. Irrigated areas</u>				
Percentage of total cropped area:	50	66	8	18
Percentage of irrigated area by:				
i) pumpsets	24	60	27	35
ii) wells	22	4	41	17
iii) canals, tanks, etc.	54	36	32	48
<u>III. Power threshers<sup>b/</sup></u>				
Percentage of crop threshed:	50	100	--	20
<u>IV. Reapers</u>				
Percentage of crop cut:	--	50 <sup>c/</sup>	--	--
<u>V. Tractors</u>				
Percentage of area expected to be covered:	3	20	0.5	5

<sup>a/</sup> Percentages refer to irrigated area under given crops.

<sup>b/</sup> In Punjab power thresher is used only for wheat. In Maharashtra it is for paddy, jowar-bajra and wheat.

<sup>c/</sup> This figure is very speculative.

may be much lower than desirable for non-owners to be able to share in the benefits.

Maharashtra. The effect of four technological changes was studied: HYV, pumpsets, power threshers, and tractors. The other three innovations considered in Punjab, corn shellers, power cane crushers and reapers, are not of much importance in the state. Maize occupies only a very minor position in cropping, and only 7 per cent of the sugarcane is now crushed with human and bullock labor. As for reapers, there is at present no visible indication of this machine gaining much ground in this state during the next 15 years, unless a cheap machine is evolved for cutting jowar-bajra which are the principal crops grown here. Wheat reapers, unlike Punjab, do not seem to offer much scope as the harvest of this crop in Maharashtra falls during the slack season.

The past performance of the state in introducing high-yielding varieties of crops has been much below expectations. In 1969, the overall achievement, in terms of area covered, was only 55 per cent of the state plan targets. Various estimates are available regarding the future targets for HYV which were taken into account in our estimate; however, in the case of jowar, the principal crop, the recommended variety (CSH-1) is not finding much favor with farmers because of its susceptibility to shoot fly and poor eating quality.

Diesel and electric pumpsets are very popular in the state in spite of unfavorable conditions. They are extensively used for lifting water from rivers and streams which flow in all parts of the state, with greatly varying discharges in different times of the year, and their number is rapidly going up. Improved paddy threshers and machines for threshing wheat, jowar and bajra have appeared

recently. By 1983/84, we estimate that nearly 1/5th of the total area under paddy, wheat, jowar-bajra will be mechanically threshed.

Due to heavy soil conditions and unirrigated extensive farming, the demand in Maharashtra is for heavy wheeled tractors of over 30 horsepower. In 1968/69 there were 4,500 of these tractors, and there were also 300 crawler tractors and 200 power tillers--with very little overall impact on labor. Heavy tractors are very costly and are mainly owned by large operators, by the state government or by sugar factories. Judging from past progress, it is estimated that by 1983/84 the state will probably have 45,000 wheeled tractors, 2,200 crawler tractors and 22,300 power tillers, commanding only 5.2 per cent of total area.

### Results

Each of the new technology inputs has a separate and distinct effect on the demand for human energy. For convenience, emphasis is placed on 1968/69 and on the terminal year, 1983/84.

Of themselves, the HYV appear to have increased the 1968/69 demand for human energy by 6 per cent in Punjab and 1.3 per cent in Maharashtra as compared to requirements for the same crops using traditional methods. However, pumpsets reduced total human demand in Punjab by 4 per cent, threshers a further 5 per cent and tractors one per cent; overall demand is reduced by 11.5 per cent. In Maharashtra reduction in labor demand by pumpsets (the only mechanizing factor considered) was negligible, being only 0.2 per cent.

By 1983/84 farm machinery is expected to become a common feature in Punjab farm practices, when it seems

- 13 -

Table 2: Changes in Demand for Human Energy:  
Effects of New Methods compared  
with Conventional Methods

(in millions of man-days required per year)

<u>Cumulative Introduction</u> <u>of Technologies<sup>a/</sup></u>	<u>Punjab</u>		<u>Maharashtra</u>	
	1968/69	1983/84	1968/69	1983/84
1) Conventional	608.7	840.6	1546.5	1703.3
2):1. with HYV	644.3	952.0	1566.9	1819.5
3):2. with pumpsets	618.2	867.3	1563.1	1808.7
4):3. with power threshers	586.8	805.3	--	1790.4
5):4. with cane crushers	582.6	790.9	--	--
6):5. with corn shellers	580.5	771.9	--	--
7):6. with tractors	574.9	726.6	--	1767.2
8):7. with reapers	--	694.4	--	--
Net Change:	-33.7	-146.2	16.6	63.9
Percentage Net Change:	-5.5%	-17.4%	1.1%	3.8%

a/ Labour requirements as shown in columns reflect changes resulting from adding one new technology after another, starting from the "conventional" base in which only pre-existing methods are used. The estimated shifts in labor requirements were: HYV 20-50% increase, by crop; pumpsets 1/4th of persian wheel; threshers 1/4th of indigenous method; cane crushers 1/5th; corn shellers 1/7th; tractors 1/5th of time with bullocks; reapers 1/5th of traditional.

possible that nearly 100 per cent of wheat will be mechanically threshed, 100 per cent of corn will be shelled by corn-shellers, 20 per cent of the gross cropped area tilled by tractors, 50 per cent of the wheat crop mechanically reaped and 60 per cent of the area will be irrigated by pumpsets and tube wells. These changes from the conventional technology are feasible if no radical changes occur in public policy regarding mechanisation and if relationships between farm costs and prices remain sufficiently favorable. With these changes in the methods of crop production, total human energy demand in 1983/84 in Punjab will be reduced from the conventional level by 17.4 per cent. The greatest displacement will occur in April and May, the harvest period, when demand will fall by 25.4 per cent and 43.9 per cent respectively. About 55 per cent of the total labor displacement is caused by tractors and pumpsets, 37 per cent by threshers and reapers, and the remaining 8 per cent by corn shellers and cane crushers.

Maharashtra presents an entirely different picture. Only 20 per cent of paddy, wheat and jowar-bajra are expected to be mechanically threshed, 5 per cent of the area tilled by tractors, and pumpsets will command 35 per cent of the irrigated area. The additional demand of human labor created as a result of growing HYV is much more than the counterbalancing effect of mechanical power in reducing labor demand. By 1983/84, with the increase in acreage under HYV, demand for labor will increase by about 116 million human labor days or by 6.8 per cent. Pumpsets will displace 0.6 per cent of the labor and power threshers and tractors 1.0 per cent and 1.3 per cent respectively. The net result will be



- 15 -

overall increase in labor demand by 3.8 per cent.

Table 3: Agricultural Workers per Cropped Hectare:  
Average Number of Days per Year per Worker  
Needed for Crops

<u>Year</u>	Punjab				Maharashtra			
	Cro- pped area (mil. hec.)	Agril. work- ers (mil.)	Wor- kers per hec.	Days per wor- ker	Cro- pped area (mil. hec.)	Agril. work- ers (mil.)	Wor- kers per hec.	Days per wor- ker
<u>Historical</u>								
1951	8.06	4.08	.51	n.a.	17.31	9.80	.57	n.a.
1961	9.73	4.54	.47	n.a.	19.09	13.25	.60	n.a.
<u>Projected</u>								
1968/69	10.46	4.70	.46	120	19.68	14.92	.76	105
1983/84	11.93	5.34	.45	130	21.05	20.47	.97	86

Table 3 presents the number of agricultural workers per hectare of cropped area in the states of Punjab and Maharashtra. During the period 1951-61, while the cropped area in Punjab increased by about 21 per cent, the recorded increase in farm workers was only 11 per cent, with the result that the average number of workers per hectare declined from .51 to .47. The ratio appears to be quite stable in the .46 to .48 range up to 1978/79, after which it decreases to .45; 1978/79 appears to be the turning point when the absolute number of agricultural workers will start to decline.

In Maharashtra, however, the density of cultivators and agricultural workers per hectare of cropped area is much higher than in the Punjab and is rapidly going up. An increase of 35 per cent in the agricultural workers as against an increase of only 10 per cent in the cropped area during 1951-61 resulted in worker/cropped area ratio increasing from .57 to .69. A similar trend continues throughout the projected period; the number of workers on farms will increase by 37 per cent and cropped area by only 7 per cent. This will result in the increase of agricultural workers per hectare from .76 to .97 or by 28 per cent.

As changes occur in the average number of workers per hectare of land, the input per worker in terms of working days in a year also changes. While in the Punjab working days per worker are rising in spite of mechanization of certain operations, they are sharply declining in Maharashtra. In 1968/69 a worker in Punjab on an average worked for crop production for 120 days and in Maharashtra for 105 days. The corresponding figures for 1983/84 are 130 days and 86 days respectively, an increase of 8 per cent in the working time of the former and a decrease of 18 per cent in the latter. (In addition, a farm worker devotes as much as 45 per cent of his total working days to farm work other than crop production such as tending of cattle, marketing of produce, purchase of inputs, etc.)

The nature of the shift in Maharashtra is consistent with what one might expect in small-scale family-centered farming, subject to rapid population growth. The additional 4.51 million fresh workers in agriculture, amounting to 22 per cent of the total labor force in 1983/84,

represent an increment of surplus above whatever surplus existed in 1968/69. Nearly two thirds of the additional labor force is estimated to be in the category of cultivators and the remaining one third as agricultural laborers. In the case of cultivators, disguised unemployment will grow markedly during the projected period; those who enter the work force will be absorbed in agriculture by work-sharing. A number of small farmers who lag behind in adopting new technology are likely to join the hired labor force. These and the additional surplus of 1.43 million agricultural laborers will substantially add to the number of workers in this class and thereby aggravate the already serious problem of underemployment and unemployment.