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Mechanization, Labor-Use And Productivity in Indian Agriculture

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MECHANIZATION, LABOR-USE AND PRODUCTIVITY IN INDIAN AGRICULTURE

In the process of economic growth different inputs keep losing or gaining their importance as available resource-mix and level of development move to a higher plane. A factor crucial at one stage may not remain so at the subsequent stage and a factor with zero or low marginal productivity might turn out to be a strategic input as the economy moves on a growth path. Something similar is happening to the use of mechanical power in agriculture in India, which has a relevance to many other developing countries with a high density of labor and low availability of capital. Till recently draft power (both stationary and motive) was generally considered to be a surplus resource in the situation of small farms operated with bullocks, mainly owned capital and abundantly available family labour as well as hired labor. Most of the farm management studies aiming at improving the resource-use efficiency, therefore, assumed, explicitly or implicitly, draft power to be a surplus resource not putting any restraint on production programs of the farmers. A few of the studies even concluded, by implication, that capital was surplus of the farm requirements. Some arguements based on studies in economics of farm management[1/] went to the extent of establishing the superiority of small farms over the larger farms, because of abundantly available bullock power and family labor[2/] Apparently convincing arguments are being put

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1/ Government of India, Studies in Economics of Farm Management (For 8 centries in India)--1954-55 to 1956-57, Directore of E onomics & Statistics, Ministry of Ford and Agriculture, New Delhi, 1959.

2/ Kahlon, A.S and S.S. Johl, "Productivity on Small Farms", The Economic Weekly, Vol. 14 (25) Bombay, 1964 pp. 985-986.

forth in favor of small farms, labor-intensive technology and against mechanization, especially tractorization, in India and other such developing economies which have abundant labor supplies and are short of capital. However, these arguments in some cases emerge out of analysis of a static picture of the economy and in many cases are theoratical abstractions. Time dimension and speed of change are, often ignored. There is, therefore, a need to carefully examine various aspects, influences and implications of introducing and enhancing the availability of machine-power, especially tractors, on the agricultural and over all growth of a developing economy such as India. Such an analysis will be helpful in delineating reasonable and feasible models of mechanical power-use in other developing countries also. This paper, with no intentions or presumptions of providing complete or in any way final analysis, is an attempt to put forth some arguments on the process and implications of introducing mechanical power in the agricultural sector of the developing economies. This paper thus specifically aims at setting the arguments on the following aspects:

(1) Relationship of mechanical power use with labor employment in the agricultural sector on micro as well as sectoral level.

(2) Subsidiary or accompanying influences of mechanical power-use in agriculture on non-farm job opportunities, and

(3) Other economies, diseconomies and influences on economic, social and political matrix of the economy.

I realize that these objectives sound a little too impressive and high ding to be fully explored in this paper. Yet, the aim of this write up is only to put forth some arguments, as far as possible supported with data to be persued further. Many of the points in arguments here will not be new, yet the purpose is to consider them from different angle.

Mechanical Power, Labor-use and Productivity

Power (both stationary and motive) is as good a resource in farming as any other resource such as land, labor and other items of capital. These

resources influence and get influenced in their productivity by the total productivity of the firm and the level of factor-use (management considered as a factor of production). Other factors and influences held constant, marginal productivity of any of these resources will follow a classic production-response path. The use of abundant (free) resource is, therefore, liable to be pushed to the point of zero marginal product. Labor is considered to be such an abundant resource in India and many other developing countries. Considerable interest, therefore, has been generated in labor use patterns and its productivity. Some considering labor to be a free (or at least abundant) resource, recommend its intensive use and do not consider it advisable to introduce mechanical power, especially tractors. Machines (and tractors) use scarce capital resources and replace abundantly available labor resource creating more unemployment with the consequences of mal-distribution of incomes and poverty of masses, outflow of labor to cities aggravating slum conditions and leading to social as well as economic polarization in the economy. These arguments look simple, straight and apparently so true that one is liable to agree out-right. But, this argument loses sight of the time dimension and the feedback influences of the process of mechanization. It would hold true if one analyses the economy as a static situation and a once-for-all replacement of human labor, or at least a major part of it, with mechanical power. There will be little room to question the argument on economic grounds because of near zero or low opportunity cost of labor and high opportunity cost of capital. On social and political grounds labor substitution with capital under the situation of millions of people unemployed or under employed, will be disasterous. This argument loses much of its validity when mechanization is visualized as a process of slow and orderly adoption of machines with all complimentary effects on demand for other inputs and in the process on demand for labor. Machines substitute for

labour in the performance of certain farm operations at a given level of output, yet it enhances the capability to perform these operations more number of times and necessitates some other operations which otherwise would have not been performed. Mechanical-power use thus has a complimentary effect on labour-employment at the farm-firm level. On farm-firm level, if mechanical-power use substitutes for labour, it does so only at an advanced phase of expansion path. The fact is often not fully appreciated that in the underdeveloped agriculture a vicious circle gets established where low level of power-use (tractors, pumps, other machines and accompanying implements) does not permit full utilization and development of other scarce resources such as intensive use of land, irrigation development, reclamation and perservation of dry and cultivable wasteland and above all timely and proper performance of farm operations. Adoption level of technological innovations thus remains low. Growth of the farm-firm, horizontally and vertically, comes to a stop. As a result, resources such as labor, which are exogenous to the business of agriculture depending upon natural growth of population, go surplus and agricultural economy establishes a low-level-equilibrium with lots of farm labour under-employed or disguisedly unemployed. No wonder this low-level-equilibrium reconciles with low capital availability and with given (traditional) techniques of production the farm-firms show no further demand for working capital[1/]. If availability of most limiting resource (capital in general and mechanical power in particular) is not enhanced, the potential of growth remains unexploited.

Unfortunately, in most of the arguments against mechanization, economist used to aggretative analysis, assume human labor and machines, supplying the

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1/ At the annual conference of Indian Society of Agricultural Economics at Anand, 1966, some participants held the view that Indian farms were not capital starved, because their existing production programmes did not show demand for working capital.

same motive-power to the farm from two different sources; which is not true. Power supplied by labor and that supplied by machines cannot be aggregated as one homogenous input. Hand labor (or labor with traditional tools) can not do that job as human hands can do with the help of machines. Often, and especially so in the initial stage of growth of agricultural economy, machines serve as better tools in the hands of workers to do certain jobs which they cannot do or do so well without these machines. Here the odds go against machines only that much as they would go against introduction of improved implements to replace traditional wooden plow! Agrument in this respect can be simplified as: (1) labor with traditional implements and labor with machines are two sources supplying two different categories of power, which cannot be aggregated, (2) second category of power is a limiting resource on under developed agriculture to keep farm-labor use and its productivity at a low level, and (3) once this restraint is removed, farm-firm expands horizontally as well as vertically to demand more labor and improve its productivity as well as increase returns to other factors of production. Let us verify this argument with the data on Punjab State in India, which is a spectacular case of fast improving agriculture and rapid expansion in mechanical power-use on farms.

Table-1 depicts the situation of a section of farmers (progressive farms) which fall in the categories of innovators or early adopters on the adoption scale. It can be reasonably assumed that what is their stage today in a cross-section of the farmer-population, can be the stage of less progressive and late adopters in the time series situation in future. I realize it is not a perfect assumption, but I believe it to be a reasonable and practicable assumption considered from the view point that economic environment, capabilities and feasibilities for an entrepreneur change in a consistant manner in a set direction as he moves on adoption path through

time. Cross-sectional stages can be, therefore, interpreted into time series stages with a fair degree of confidence in this case. It can be, therefore, safely assumed that over time other farmers will be what progressive farmers are today. As the rate and degree of change in agricultural adjustments slow down at higher levels, there will be higher and higher concentration on upper levels of adoption curve and more farmers will enter the category of progressive farmers. May be the speed is different, the direction of change will be the same. Real move towards mechanization of farm operation in Punjab started in the year 1966-67 as a result of introduction of high yielding wheat varieties, demanding higher use of fertilizers, more irrigation and more careful management. Coupled with assured high prices, higher yields on this crop and some others such as maize and ground-nut made it remunerative to reclaim culturable wastelands and use cultivated lands more intensively. Bullock power available with the farmers turned out to be incapable of doing these jobs. Bullock power, therefore, started being substituted by tractors wnd pumping sets operated with electric and oil engines. This substitution was especially necessitated by the serious inability and inadequacy of bullock-power to do harvesting and sowing operations in time to leave sufficient margin for preparation of fields for the following crop and to save the crop from damage by rains. Since the new varieties of crops required higher dozes of fertilizer, irrigation, cultural operations and after-care, demand for labor exceeded the availabilities on the farms. Mechanization of farm operations under the new economic environment, thus started taking place generating forces that made it possible to increase intensity of cropping, bring new lands under cultivation and perform agricultural operations more intensively, timely and properly. As a result demand for labor increased and continued increasing. It is showing no signs of decline so far. Figures in Table 1 provide magnitudes of these

changes in respect of a sample of progressive farms in the state. Over a period of four years average cultivated area increased by about 11%. Cropped area increased by over 26% with an over-all intensity of cropping increasing from 126.69% in 1966-67 to 144.26% in 1969-70. As a result of this expansion in crop acreage horizontally as well as vertically labor-use on the farms increased by over 58 percent during this period. This increase in intensity was made possible through the use of tractor power and water pumping machines. Tractor power use increased by over 44 percent. Tractors and pumping sets coupled with wheat thrashing machines replaced bullock power, reducing its use to less than 28 percent of what it was in 1966-67. These data show a high degree complementarity in mechanical power use and labor employment on farms. Substitution took place only for bullocks (animal draft power).

Punjab Board of Economic Enquiry data also support this line of argument: Table 2 provides data on three selected years over a period of more than ten years. Although no direct conclusion on association of mechanical power use and labor employment can be drawn from these data, because information on degree of mechanization of these farms is not available, it can be safely assumed that this sample of farms also got mechanized to the same degree as others in the state. If degree of mechanized of these farms is assumed to be fairly high as on average farms, increase in labor use and intensity of cropping suggests a high degree complimentarity between mechanical power-use and labor employment: compared to 1955-56, employment of farm workers in terms of number of days employed in a year increased by about 26 percent in 1964-65. As process of mechanization proceeded faster in the next three years, employment increased by another 24 points. Not only employment increased in terms of number of days worked during the year, it also increased in terms of number of hours worked in a day. Where as over-all employment increased by 64% in one decade of slow adoption of improved technology and mechanization, it increased by further 66 points

Table 1

Changes in Farm Labour, Bullocks and Tractor Use in Punjab based on a sample of progressive farms in Punjab*

Year	Average Acreage		Intensity of Cropping	Total Labor Used (M. Hours)	Labour Used		Bullock hours used per cropped acre	Tractor hours used per cropped acre
	Cultivated	Cropped			per cultivated acre (M. Hours)	per cropped acre		
1966-67	33.19	42.05	126.69	11481	273	246	127.53	11.94
1967-68	33.87	44.73	132.06	13821	309	408	76.15	9.58
1968-69	36.85	49.89	135.39	16310	327	443	48.4	12.72
1969-70	36.78	53.06	144.26	18145	342	490	35.66	17.24

*From the files of Department of Economics and Sociology, Punjab Agricultural University, Ludhiana.

Table 2

Manual labour put in per farm-worker and intensity of cropping in central Punjab (Based on Farm Accounts in Punjab)

Year	Days per anum	Hours per day	Intensity of cropping
1955-56	196.1	4.35	137.5
1964-65	243.5	5.34	144.4
1967-68	295.5	6.46	155.3

Source: The Board of Economic Enquiry, Punjab, Farm Accounts in the Punjab, 1955-56, 1964-65, 1967-68.

Table 3

Changes in returns per anum to various factors of production employed in Agriculture, central Punjab, 1955-56 through 1967-68 (Based on Farm Accounts Data)

(Rs)

Year	Per family worker	Per permanent hired labourer	For management	For farmers' labour and management	To farm capital (Excluding Land Value)
1955-56	478.82	452.97	-485.33	-22.60	37.77
1964-65	1717.28	723.41	-216.34	502.92	58.93
1967-68	3271.47	1152.92	712.39	1857.87	86.70

Source: The Board of Economic Enquiry, Punjab, Farm Accounts in the Punjab, 1955-56, 1964-65, 1967-68.

in three years of rapid adoption during the period 1964-65 through 1967-68. Intensity of cropping during this period showed the same trend. It increased only by 6.9 points during 1955-65 decade but increased by 10.9 points in next three years. By implication these data suggest complementary in power use, increase in intensity of cultivation and labor employment.

Table 3 indicates what happened to productivity of (measured in terms of returns to) various factors of production on the same sample farms for which accounts were maintained by the Punjab Board of Economic Enquiry. Figures show a trend of rapid increase in returns after 1964-65. Returns to permanent hired labor improved by 59 points in the decade 1955-64 and by 96 points further in three years 1965-68. Returns to management improved appreciably in the first period, but still remaining negative. In the second period returns improved tremendously from a negative of Rs. 216.34 to a positive figure of Rs. 712.39. Returns per family worker for farmer's labor and management and returns to farm capital improved in the same manner, with a much higher rate of growth in the second period compared to the first period.

Yet an other study[1/] indicates as in Table 4 that in terms of productivity of land, yields per acre of almost all the commercial crops were found to be higher in case of tractor-operated farms compared to bullock-operated farms, both under tube-well as well as canal irrigated conditions. It is not possible here to separate out the effect of tractor-use on yield from that of fertilizers, irrigation, labour and other inputs that went with it to throw up this difference. Tractor input goes in package with other inputs, serving essentially as an enabling factor, without which other inputs would not be used at that high level. Availability of tractor-power would thus

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1/Dept. of Economics and Sociology PAU, Studies in Economics of Farm Mangement; Ferozebur district Punjab (unpublished) Ludhiana, 1968-69.

Comparison of Yield Per Acre of Various Crops
on Tractor and Bullock Operated Farms
in Ferozepur District of Punjab
1968-69

Crop	Yield in Quintals Per Hectare			
	Tube-well Holdings		Canal Irrigated Holdings	
	Tractor Operated	Bullock Operated	Tractor Operated	Bullocks Operated
Wheat Local	13.82	0.62	---	---
Wheat Mexican	24.70	9.81	25.65	22.46
Maize Local	15.62	3.55	---	---
Paddy	28.36	4.17	---	---
American Cotton	---	---	10.15	8.36
Desi Cotton	8.47	6.96	9.25	7.71

Source: Studies in Economics of Farm Management, Ferozepur District Punjab, Department of Economics and Sociology, Punjab Agricultural University, Ludhiana, 1968-69.

enable a farmer to use more irrigation, fertilizers, labour and other inputs per acre in a package shifting the production function upwards. Here the element of seasonability in the farm operations is another factor which necessitates the use of mechanical power in order to increase output and create farm-work in off seasons. Harvesting and sowing operations come up all in short periods of October-November and April-May in Punjab. In these periods it is a question of timely sowings and harvests. Without machine-power these operations get delayed, resulting in lesser acreage under crops and damage to harvested crops by rains. Mechanical power use enables expansion of acreage under crops through meeting demands of peak-work load periods creating jobs for labour in tending to the crops during their growth period and in handling larger volumes of harvests. The marginal productivity of labour and its employment thus closely depend on and is inter-linked with machanical-power input in agriculture where seasonability factor gives rise to acute work-load peaks.

All these data from different sources support the argument that at this stage of development and in the near future, mechanization of farm operations will absorb more labor as a complementary input on farm-firm level rather than substituting for it. Punjab data and experience show that there is no evidence to believe that mechanization in a way replaced labor so far. In fact Punjab farms in general have gone short of labor supply. In spite of a lot of employment made of the labor from adjoining states of Rajisthan and U.P., it is not uncommon to observe seeding and harvesting of crops getting delayed, hoeing and other cultural operations not performed or performed inadequately due to shortages of labor supply. As a result of this excess demand, wages have been shooting up and farmers complaining of rising costs. This inter-action is conceptulized in diagram 1. Although the diagram is not data based, yet over all picture of the Punjab economy would yield similar

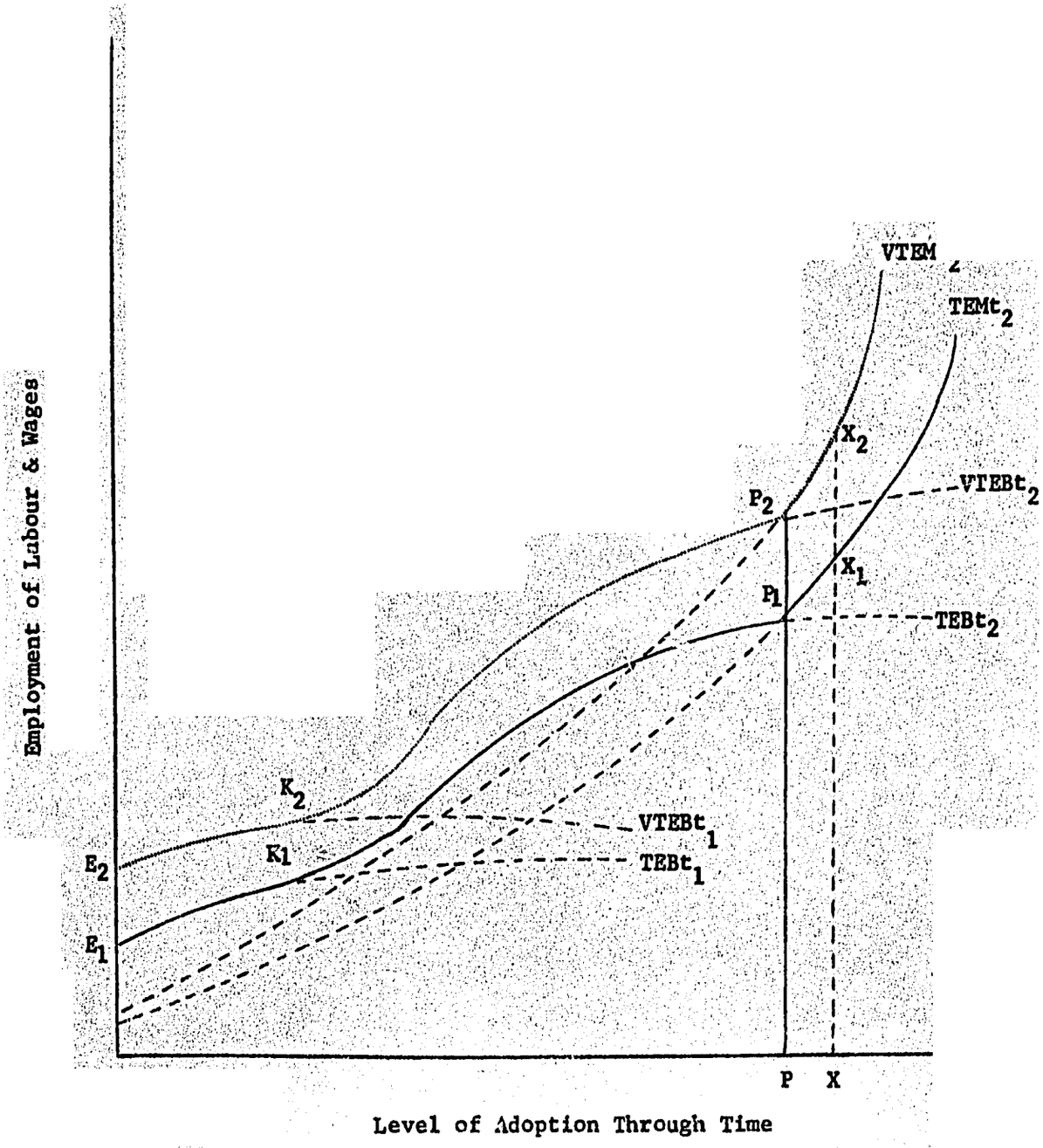

Figure 1. A CONCEPTUAL ILLUSTRATION OF THE INTERACTION OF ADOPTION OF NEW CROP PRODUCTION TECHNOLOGY & MECHANIZATION WITH LABOUR USE & WAGE PAYMENTS

general trend. Had there been no breakthrough in crop production technology employment of labor would have followed a path similar to E_1-K_1-$TEBt_1$[1/] and labor wages E_2-K_2-$VTEBt_1$. Influence of improved crop production technology in the absence of mechanization would have been as of K_1-P_1-$TEBt_2$ on employment and K_2-P_2-$VTEBt_2$ on wage levels. Mechanization interaction with improved production technology shifted the labor-use to wage curves still up as P_1-$TEMt_2$ and P_2-$VTEMt_2$ respectively

Mechanization earlier to BP_1-P_2 stage would have probably caused unemployment through substitution of machine power for labor. Most of the arguments against mechanization are based on assumptions of this situation; which is not true, as shown by the data in Table 1 through Table 4. Agricultural economy of the state is at present operating at a stage somewhere depicted by the line X-X_1-X_2. This stage could have not been reached without the mechanization of farm operations such as power lifting of underground water for irrigation, thrashing of wheat with mechanized thrashers and intensive as well as extensive cultivation of land with tractors.

The process of interaction of mechanization with labor-use and productivity can be further illustrated as in diagram 2. As the state of tech nological improvements and their adoption improves on X axis, labor use and its productivity[2/] increase and move on EB_o path. Up to a certain stage introduction of mechanical power will remain uneconomic, considered from the point of view of labor employment and earnings. This point is indicated by B_o. If mechanical power is used below this point, labor use and earnings will

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[1/] $TEBt_1$ stands for total employment with bullock economy and old production technology. $VTEBt_1$ stands for value of $TEBt_1$, indicating wage level. $TEBt_2$-Total employment with bullock economy and new production technology. $VTEBt_2$-Value of $TEBt_2$. $TEMt_2$-Total employment with mechanization and new technology. $VTEMt_2$-Value of $TEMt_2$.

[2/] Although labor employment and productivity can move in opposite directions, yet I assume and believe, they move in the same direction (upwards) as the production technology using given resources improves.

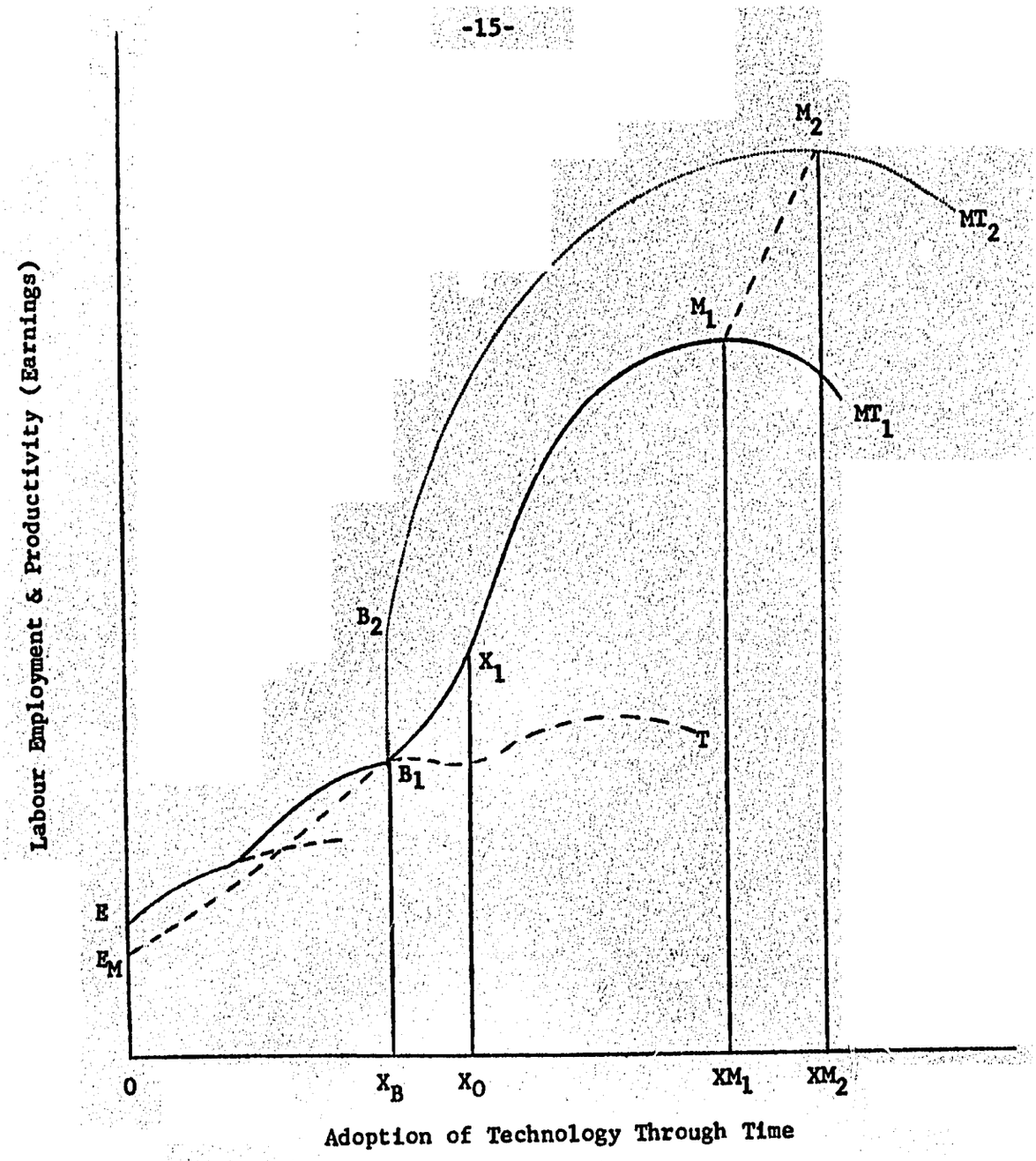

Figure 2. CONCEPTUAL ILLUSTRATION OF THE INTERACTION OF MECHANIZATION WITH FARM-LABOUR EMPLOYMENT & ITS EARNINGS IN DEVELOPING COUNTRIES

follow EMB_o path which is below EB_o. Only at this breakeven point and beyond, technology and its productivity permit mechanization (as it happened in Punjab after 1966-67, when technological breakthrough made it not only feasible but expedient to use mechanical power because of inadequacy and incapability of available human and bullock power to meet with the requirements of the new technology). In the absence of mechanical power-use, labor employment and productivity would move on B_oT curve. But interaction of mechanical power with other technological improvements will shift labor-use and its productivity on B_o-M_1-MT_1 path. Further improvements on production technology will shift the employment productivity curve upwards as indicated by B_o-H-M_2-MT_2 curve. Every subsequent technological improvement will shift this curve upwards pushing maximum employment productivity point up and to the right as indicated by the path M_1-M_2. There is thus no point in opposing or supporting the introduction of mechanization per se in the agriculture of developing countries. It all depends at what stage of development other elements of production technology are; and what level of mechanization has already been achieved. Developing economies are at a stage where this positive interaction has yet to start; where it has started it is increasing at increasing rate as shown in case of Punjab. Mechanization is highly desirable up to the point M_1, till total farm-labor employment, and its productivity keep increasing. Substitution of labor takes place only beyond point M_1 on the expansion path. If production technology improves further, this maximum employment productivity point will go further beyond upwards. In most of the arguments against mechanization, situation assumed is either lert to B-B_o line or is based on the experience in developed economies beyond X_{m1}-M_1 line. Both the assumptions do not hold true with the present level of availability of technical know-how to the developing countries. Thus, cautious of 'M' points, there is no reason to throttle the growth of employment and its productivity in the developing economies with a bias against

mechanization when technological development and its adoption starts putting labor employment and its earning on the path B_o-M_1 with future possibilities of its being shifted still upwards to the right.

The situation can be further explained with a simple diagram as in Fig.3. With the given technology (traditional methods) total output is low at T_1 and resources use (capital and labor combination) is at point O_1 on T_1 production possibility curve. Machinery (capital) can be substituted for labor only at the cost of employment and wages as it will shift resource combination from P_1 to the direction of P_2 or, otherwise more labour-intensive technology can be used, as resource-use combination moves from O_1 to P_1. With the improved technology the production possibility curve will shift to T_2 if mechanization of farm operations is made possible shifting resource use from O_1 to O_2. At this point labour employment will be at L_o^2. More labour-intensive technology will shift resource use combination towards P_3 and to L_3. In order to make it possible for employment and labor productivity to increase from L_1 to L_3, (most intensive use of labour with new technology), it is necessary to invest capital (mechanization) at least up to C_3. Further it is a matter of social and economic considerations, whether it will be desirable for an economy to increase capital investment on machinery beyond C_3 point, yet there should be no dispute on a shift from Point P_1 to P_3 even if most labour-intensive technology is to used, especially when marginal productivity of capital investment goes in favor of agriculture compared to non-agricultural sector investments.[1/]

1/ There are evidences available that MVP of capital in agriculture is very high. Singh, Gurder estimates it at Rs. 2.93 and 4.37 for medium sized, bullock operated well irrigation farms in Ludhiana District. There are many other such studies of the Department of Economics and Sociology of PAU Ludhiana and of other agricultural research institutes and universities in India which have shown MVP of capital to be very high in agriculture.

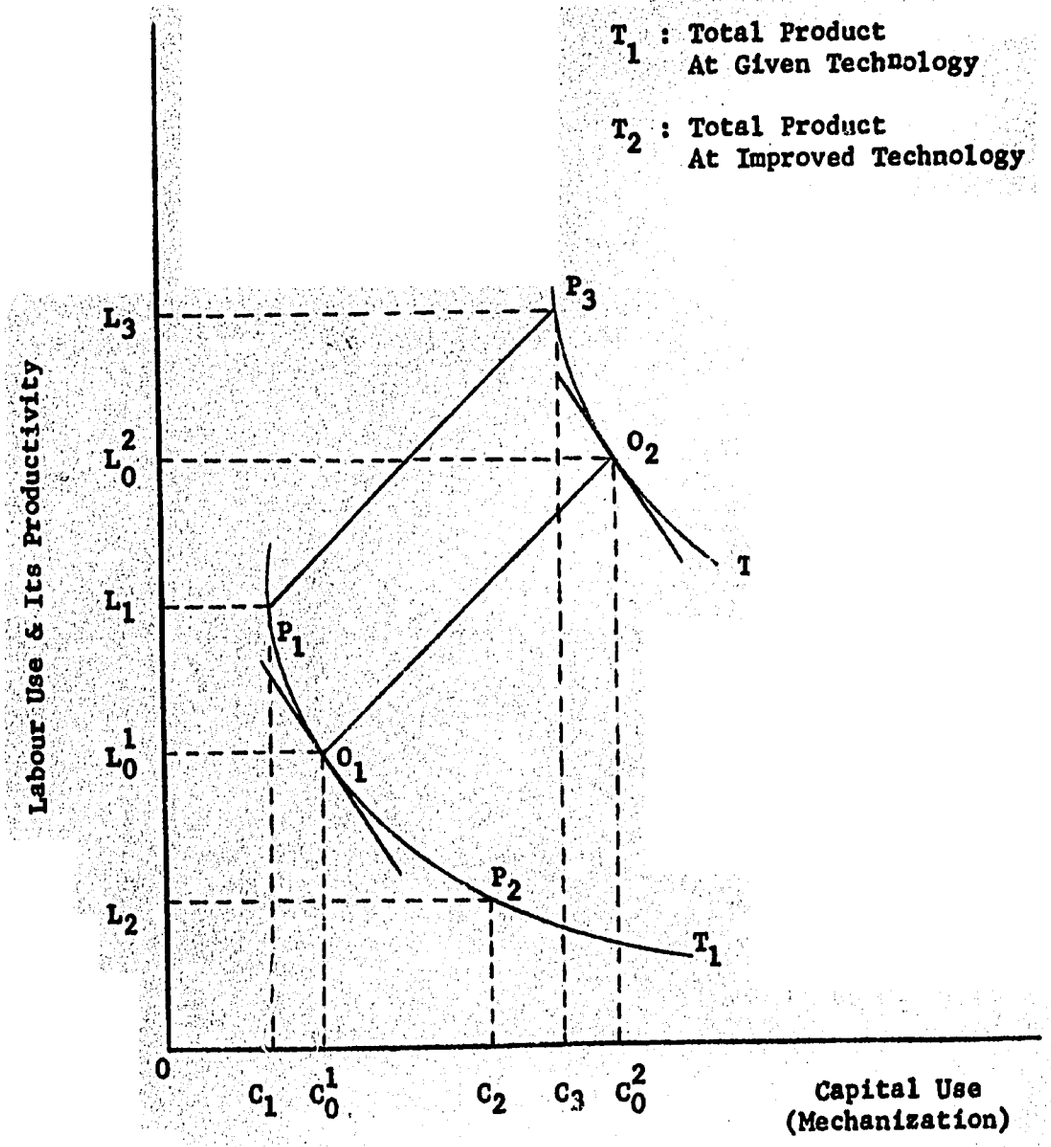

Figure 3. INTERACTION OF MECHANIZATION WITH TOTAL PRODUCT, LABOUR EMPLOYMENT & LABOUR PRODUCTIVITY

Macro-Level Employment and Wages

Looking at the picture of agricultural economy of the state as a whole, as shown in Table 5, argument in farm of mechanization finds still further support. Up to the year 1966-67, workers employed in agriculture as a percentage of total work force in Punjab kept declining. But a sharp rise came in 1967-68, as technological innovations have had their influence felt. Cultivated area per worker kept decreasing in response to natural increase in rural population, an exogeneous variable to the agricultural industry. Through mechanization of farm operations working condition in agriculture became more attractive and renumerative. Agriculture, therefore, started attracting more of work force; many who had earlier left for employment outside returning to farms. In spite of this increased population pressure on agriculture, interaction of mechanization with other elements of improved production technology increased cropped area per worker. Whereas net cultivated area per worker declined from 2.23 hectares in 1960-61 to 2.04 hectares in 1966-67 and to 1.82 hectares in 1967-68, corresponding cropped area per worker, remaining almost constant with minor variations up to 1966-67, increased sharply from 2.73 hectares in 1966-67 to 3.79 hectares in 1967-68. This would have not been probably possible without interaction of machanical power with other elements of improved production technology such as development of high yielding varieties of crops, fertilizers and other packages of farm practices. Structure of wages also presents a similar picture. Both for agricultural operations and skilled-job operations wages have been improving, particularly after the year 1966-67. In three years from 1967-68 through 1969-70, wages for plowing increased by 61 percent, for sowing operations by 64 percent, weeding 60 percent and harvesting 89 percent. All these are unskilled jobs. For other skilled jobs in agriculture, wages improved by 70 percent during this period of three years. Wages of blacksmiths

Table 5

Agricultural Employment, Unemployment, Wages and Other Allied Statistics in Punjab, 1960-61 through 1968-69

	1960-61	1965-66	1966-67	1967-68	1968-69	1969-70
'ct. of workers engaged in agriculture	55.89	54.48	54.21	55.84	-----	-----
ultivated area per agricultural worker	2.23	2.06	2.04	1.82	-----	-----
Cropped area per ag. worker	2.77	2.64	2.73	3.79	-----	-----
Wages paid/day						
a) Ag. labour:						
1. Ploughing	2.50	3.45	3.82	4.27	4.70	6.15
2. Sowing	2.49	3.40	3.73	4.18	4.74	6.12
3. Weeding	2.65	3.31	3.66	3.94	4.59	5.83
4. Harvesting	2.59	4.01	3.94	4.93	6.14	7.43
5. Cotton picking	2.00	2.69	----	4.00	4.00	3.97
b) Skilled labour:						
1. Other agr. operations	2.49	3.02	3.51	4.14	4.71	5.97
2. Black smith	4.24	5.46	6.12	7.02	8.29	10.20
3. Carpenter	4.41	5.46	6.08	7.11	8.61	10.20
Unemployment						
a) Total according to live register	35220	----	50578	58627	72071	-----
b) Farm, fishermen, hunters and related workers	559	----	437	498	321	-----

improved by 66 percent and of carpenters by 68 percent.[1/]

Unemployment figures indicate that where total unemployment in the state has been increasing as a result of natural population growth and migration from other states, unemployment registration for agricultural workers has been very negligible and further declining. In 1968, more than one-third of the registration on live register was of the persons seeking professional, technical, administrative, executive, managerial, clerical and related jobs, more than one-fourth of craftsmen, production, process, transport and communication workers and again more than one-third registration was for unclassified occupations.[2/] There is thus no evidence of substitution for labor in agriculture on aggregate level. Infact agriculture has been developing its capacity to absorb more and more labor out of increased work force generated by exogenous factors of natural population growth and migration. Unemployment situation in the state, in fact in the whole country, is of soaring number of white-collar-job seekers inadequately trained, rather untrained, for doing any specific skill-job. Majority of those registered for clerical and administrative jobs is of simple matric, higher secondary or B.A. pass. Traditional attitude of seeking white-collar-jobs after schooling persists and education is not obtained to acquire skills for entering business, trade or industry. Whereas agricultural development involving interplay of mechanization and other elements of improved production technology has generated considerable complementary demand for labor and has increased returns to the factors of production, a corresponding shift in emphasis on job oriented training has not as yet occured in educational system.

1/ Consumer price index for agricultural labourers in Punjab and Haryana with base 1950-57 was 194 in 1967, 191 in 1968 and 196 in December 1969.

2/ Government of Punjab, The Statistical Abstract of Punjab, 1969-70.

Mechanical Power-Use in Agriculture and Its Influence on Non-farm Jobs

With the introduction of machines in agricultural production, many healthy influences are felt in the non-agricultural sector. To mention a few, manufacture of electric motors, oil engines, pumping sets, thrashers and other power-drawn tools and implements got started in the state, commercial firms increased in number and expanded volume of their business and trading shops expanded and increased in number. As a result employment opportunities expanded outside of agricultural sector. This influence of sure spread to the outside of state too. Not even accounting for the positive impact on non-farm employment outside of state, Table 6 shows a cognizable expansion of off-farm employment: production of agricultural implements and machine tools increased from the value of Rs. 1205 million in 1965-66 to that of Rs. 1615 million in 1967-68 with a corresponding increase in employment from 23942 persons to 26742 persons. Number of trading shops increased from 98329 in 1965-66 to 112982 in 1968-69 with an increase of employment from 37511 persons to 39834 persons.[1/] Similarly, commercial establishments increased from 30776 in 1965-66 to 35943 in 1968-69 with an employment increase from 41597 to 48341 persons. These are of course only a few and direct visible influences. These secondary and tertiary influences are very far reaching and permeate through the economy as an injection spreads through the veins and arteries of a living body; and they are hard to be quantified. A very outstanding influence for example is on the number of repairs and spares service-shops, on which reliable data do not exist. It is, however, a common knowledge that in cities, small towns and roadside villages a large number of mechanic-workshops have sprung up which deal with servicing and

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1/ Number of employees is of paid workers. Number of shops, majority of which are operated by the owners, therefore, exceeds the number of employees.

Table 6

Growth of Non-farm Job Opportunities in Some Selected Industries and Establishments Influenced by Agricultural Development, Punjab, 1965-66 through 1968-69

Year	Manufacture of Agricultural Implements and Machine Tools		Shops		Commercial Establishments	
	Production	Employment	Number	Employees	Number	Employees
	(Lakh Rupees)	(Number)				
1965-66	1205	23,942	98,329	37,511	30,776	41,597
1966-67	1456	25,936	98,087	35,601	30,458	43,311
1967-68	1615	26,742	104,356	37,896	33,289	44,448
1968-69	1764	---	112,982	39,834	35,943	48,341

repairing of electric motors, oil engines, tractors and power drawn tools and implements. But for use of machines and tractors in agriculture, there would have been no such establishments which today provide gainful employment to a large number of skilled workers. This process is going on. Mechanics and facilities needed for repairs servicing of tractors and other machinery are short of demand in the state. As yet farmers have to travel considerably long distances to avail of these facilities are pulling nearer to the villages, because increasing volume of business makes this spread-out an economical proposition. A further increase in the degree of farm mechanization is therefore expected to have a considerable spread-out effect on creating off-farm skilled job opportunities in the small towns and even villages of the state.

In this analysis, increase in non-agricultural employment as shown in Table 6, is not entirely due to mechanization and expansion in the agricultural sector. Some increase would have been there even independent of growth in agriculture. One has to, however, remember that more than 76% of the population in Punjab lives in villages and is dependent on agriculture Total economy of the state is overwhelmingly agriculture-based. No wonder, therefore, non-agricultural economy and employment experienced a distinct upswing coinciding with so called green-revolution in agriculture of the state. Sharp rise in non-agricultural production and employment after 1965-66 is a monumental evidence of this influence.

Economies and Diseconomies Involved

The foremost problem that faces the adoption of mechanical power on farms in the developing countries (especially in India and other such densely populated countries) is the small size of farms. India for example has only

1.8 hectare average size of holdings.[1] Small size should not, however, be any major hurdle. Firstly averages do not reveal the complete picture. Fairly good-scale mechanization of farm operations can be effected on majority of above average-sized holdings. A small average is not a complete hinderence in the way of introduction of machines. For example more than 25 percent of the farms commanding 69% of the cultivated area in India can conveniently mechanize most of their farm operations.[2] Secondly, some machines fall under fairly small scale technology such as small size water pumps, engines, thrashing machines, and chafing machines. Partial mechanization is thus possible on almost all sizes of farms. Problem, however, is mainly with larger machines of indivisible character, such as tractors and combines. Here again small size should not be an absolute hinderence. Small sized tractors with BHP between 15 to 20 can be profitably introduced on holdings around 8-10 hectares capable of intensity above 150%.[3] But the majority of holdings in India are small (39 percent of the holdings are less than one hectare commanding 7 percent of cultivated area and 75% less than 3 hectares commanding 31% of the area). Here often cooperative and joint farming approach is advocated. Whole complex of cooperative departments and organizations at state and central (federal) level are endeavouring in this direction. Given the economic and social values in India (it is true of most of other developing countries also), I do not believe,

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1/ Government of India, India: Pocket Book of Economic Information, Ministry of Finance, Department of Economic Affairs, New Delhi, 1969.

2/ These farms are above 3 hectares each, 50% of the area is of farms over 5 hectares and 29% above 10 hectares.

3/ A study conducted by M. L. Gupla for his graduate disoertation (unpublished) at Department of Economics and Sociology of PAU, found that comparws to use of bullocks and differenz size tractors and pumping sets, DT-14 tractor (14BHP) doing both traction and stationary work turned out to be the most profitable proposition for a 15 acre farm.

cooperative or joint farming approach, on voluntary basis, can break much ground. Management, with individualistic aspirations and angles, is the major problem which has remained unsurmountable so far. This approach as such does not, therefore, has any bright future, unless these economies move towards collectivization with elements of complusions -- a socialistic approach. Without in any way reflecting on this system, analysis here is confined to the situation under democratic set up without any elements of compulsion. Cooperatives under this set up, while seeking to provide an alternative to socialistic collectivization, are not tuned or destined to succeed in any major way. How will small farms then acquire a size of business to permit mechanization? Answer is showing up in a spectacular case of Punjab farms. A study brought out[1/] that more than 30 percent of the owners of tractors rented in land and 80 percent did custom work. Custom hiring has the advantage of firm commitments and easy managerial decisions because of business considerations both on the part of owners of the machine and those who hire. Wheat thrashing has been almost completely mechanized. Tractor hiring for plowing, seedbed preparation and sowing is becoming increasingly popular. Purchase and sale of water pumped through privately owned tubewells nd pumping sets is a common sight. These activities have a scope to expand onsiderably. As shown in Table 6, bullocks as source of draft power are eing replaced fast. This trend is likely to speed up with custom hiring f machine services becoming more and more common. Owning of machines may ot thus be economical for small farm, if operations are limited to only wned holdings, yet custom hiring and renting in activities would permit the cale of operations to expand to make the use of machine-power economical.

1/ Department of Economics and Sociology, "A study on utilization of tractors on selected farms in Punjab", (Unpublished), PAU, Ludhiana, 1969.

In the process, large and medium size mechanized farms improve their size vertically and horizontally and small farms expand vertically through land renting in activity and/or sell services of machines excess of their requirements. Those farms which do not own machines also expand their size vertically and horizontally through custom hiring-in services of machines. Here in the process, cash needs (for working capital) of small farms increase demanding adequate institutional credit facilities to be provided for.[1/]

Considered from another angle, there exists an operational relationship of the farm size with the minimum power-unit available to the farmer. Land holdings from this point of view can be classified into two categories i.e. owned holdings and operational holdings. It is not necessary that the size distribution of two categories of holdings should move in the same direction In Punjab (the case under analysis) average owned holding is 7.5 acres. It is, however, rare to find an operational holding of this size in the villages. Most common (Modal) size of operational holding in the central Punjab till recently has been 12-14 acres. This has been so, because the basic minimum power unit available to the farmers was a pair of bullocks. With the given technology this size of holding was the optimum unit for a pair of bullocks. Depending upon irrigation facilities available, texture of soil, etc., the modal size varied from area to area around the capacity of a pair of bullocks to do the farm jobs. In drier light soil areas and canal irrigated areas most common size of operational holdings turned out to be larger at 18-20 acres still revolving around the basic power unit--a pair of bullocks. Whereas average ownership holding has been decreasing in size over time as

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1/ There can arise a question of opportunity cost of this capital. Considering the high degree interaction of mechanization with adoption of improved technology, labor-use and productivity of factors of production, I will consider the economic and social returns from this investment to be higher than the opportunity cost of this capital.

a result of farm population increase leading to sub-divisions, operational holding size has not been affected any adversely. With the introduction of small tractors and other machines, discernible changes are coming about. The operational size of the holdings is increasing to match with the requirements of the new power-units. Small ownership holding is not thus an absolute hurdle in the way of mechanization. In this process, size of operational holdings will increase through renting-in activity. It will also permit small farmers to use machine-power without owning the machines and in the long run introduce an element of mobility in the farming population enabling many small farmers to become part-time farmers and even quit farming as job opportunities develop outside of agriculture, partly initiated by the process of mechanization itself.

Another important aspect of the economics of replacing bullocks with machine-power is saving of land that goes under fodders for draft animals. According to 1966 counts[1/], there were 1286200 bullocks in Punjab and 287600 male calves between the age of one to three years. In addition to these, there were 247200 He-buffaloes used for draft purposes and 11170 male-buff-calves in the age group one to three years. Even at the conservative rate of 0.2 acres per head, these male-animals require at least 456540 irrigated acres of land, capable of growing two crops a year, for fodders.[2/] Since this land is often the best piece of land, near to the assured irrigation source (tubewell or a pumping set) there is every reason to believe that only good land capable of producing two crops a year gets allocated to

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1/ Director of Land Records, Punjab -- quoted as source in Statistical Abstract of Punjab, 1969.

2/ In Punjab there is not much of pasture land. Almost all fodder needed for animals has to be grown. Normally very fertile irrigated land is put under fodder crops.

fodder activity. Opportunity cost of this land being very high[1] this land should be allocated under best paying crop rotation, if need of fodders gets eliminated through replacement of draft animals with mechanical power. If we assume that alternative activity on this land will be wheat-maize rotation, this land will produce more than 1.14 million tons of food grains (half wheat and half maize)[2] From national point of view, opportunity cost of growing fodders for draft animals in Punjab is thus 1.14 million tons of food grains.

Considering money returns on this land, this will approximately yield additional Rs. 595 millio[illegible] per year as returns to the fixed farm resources of the farmers. This amount of additional income will be sufficient to pay for the price of more than 23000 20-BHP tractors per year.

In an attempt on economic analysis of such a cognizible change involving the basic structure of agriculture one should scrutinize carefully also the probable adverse effects it might have on the economy. Although in the context of mechanization process as it is taking place in Punjab (as a case), there appear to be no such implications on labor employment (inside and outside of agriculture), its productivity and returns, yet some peripheral questions would need to be answered, before one would go convinced of its feasibility and desirability. 'Will mechanization be having the same com-

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1/ Singh, I. J., estimated opportunity cost of Rabi-land allocated to fodders to be Rs. 1153.13 per year in 1965 (Graduate Research, University of Wisconsin, Madison, unpublished). Due to tremendous technological breakthrough after 1965, opportunity cost of such lands can be reasonably assumed to have at least doubled by 1969-70.

2/ Yield levels assumed here are 12.5 quintals of wheat and 12.5 quintals maize per acre. This is the most common yield level for these crops with improved varieties on such lands in Punjab.

3/ Singh, Gurdev, estimates Rs. 1304/- per acre as returns over variable costs for wheat and Rs. 657/- for maize; on tractor operated farms in Ludhiana district (an unpublished graduate-research dissertation) PAU, Ludhiana, 1970.

plementarity effect on labor on unirrigated lands' is one of such questions. If it does not, it has many economic, social and political implications involving widening of regional disparities in incomes leading to economic and social polarization and political strains on the system [1/] If the society is considered as a single entity, not regions or groups, it should not create much of a worry, because additional product and incomes generated anywhere (with groups or in regions) can be distributed equitably through a well structured system of taxation and transfer payments[1/] But political system remaining as it is and regional as well group pulls and pushes being very much there, it is so very important not to let regional and group income disparities widen, particularly with the instrument of allocation of scarce national resources consistant with their marginal productivity. It is therefore, imperative to examine the impact of a very crucial structural change such as substitution of machine-power for animal-power in agriculture. India has vast areas of dry lands suffering from inadequacy of total precipitation and timely rainfall. Whatever precipitation is received, it concentrates in less than three months--mid-June through early September. Crops suffer from insufficiency or total lack of moisture for major part of the year, while a major portion of rainwater drains off during monsoon periods Here it is a question of timely and proper preservation of rainwater to be used by the plants during their growth over dry periods. Also here the problem is of properly and timely seeding of crops. Animal draft power (poor in health as the animals are in these areas) is not sufficient and appropriate enough to do these jobs efficiently. In dry areas tractors can do a good job of timely and effective conservation of moisture, which is not possible to do so with bullocks. This is the basis of interaction of

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1/ This question will be discussed in detail in an other work.

mechanical power with productivity creating more work to do on hoeing, weedings, harvesting, thrashing, transportation and marketing. It is a question of providing the much lacking motive power to get the process of crop cultivation started more intensively and on a wider area. Once mechanical power makes it possible to grow crops on a wider area, more hand jobs get created and frequency of operations increases. In these areas lack of necessary and sufficient motive power is putting the biggest constraint on production programmes. Once this constraint is removed, the complementarity with labor use and its productivity starts playing up. This is evidently visible in dry areas of Haryana state in India where wages have increased from Rs. 3.96 per man day in 1967 to Rs. 4.68 in 1969 for plowing, from Rs. 3.99 to Rs. 5.03 for sowing, Rs. 3.51 to Rs. 4.24 for harvesting, Rs. 4.55 to Rs. 4.95 for weeding operations and from Rs. 3.55 to 4.42 for other agricultural operations. For blacksmiths and carpenters this increase has occurred from Rs. 5.98 to Rs. 8.32 and Rs. 4.60 to Rs. 8.49 per day respectively. Even women labor wages for picking of cotton have increased from Rs. 3.20 to Rs. 3.89 per day.1/ Rising wage rates are direct indications of increasing demand for labour. This increase in wages indicating increasing demand for labor is the net result of various elements of improved technology such as new seed, fertilizers and water use interacting with mechanical power made available in the form of tractors and water pumping engines and electric motors. Another aspect of employment deserves emphasis at this point. Although these figures show a wage rise for the same types of jobs over time, yet mechanical-power-use creates new jobs involving handling of machinery, which need higher mental skills. This improves the

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1/ Government of Haryana, Statistical Abstract of Haryana, 1969-70. Consumer price index for agricultural labourers in Punjab and Haryana with base 1950-51 was 194 in 1967, 191 in 1968 and 196 in December 1969.

quality of the human element providing a base for a progressive outlook and even change in the values of the majority of the people. Developing nations cannot ignore these dimensions of the healthy influences of mechanization of their agriculture.

What will happen to the earnings of cattle breeders in this process is another question that figures up. Fortunately the bullock breeders and raisers are not solely dependent upon this activity. They are crop farmers too. Resources (land and other) that are devoted to raising of male animals can be easily diverted to raising of commercial crops or otherwise to raising of milch animals. In fact there exists a competitive relationship between breeding the animals for draft purposes and for milk purposes. In animal breeding programs more we gain on draft, more we lose on milk and vice versa. Dual-purpose animals cannot be ideal milk yielders and have excellent draft power at the same time. If efforts are directed towards breeding the animals for milk purposes alone it is easier to develop high milk yielding breeds. Thus, as the need for draft animals decreases, it eliminates the duality of purpose in breeding programs and improves the milk yields. At the same time resources being used in raising draft animals get released to be used for raising milch animals. The gains of the cattle-raisers on more and better milch animals should thus more than balance out their losses on elimination of draft-animal-raising-activity.

In balance there seem to be few arguments, logic or facts that should cast doubts on economic feasibility of substituting totally inefficient animal draft power with mechanical power in agriculture of the developing countries, which will generate positive interaction with other elements of improved production technology, creating more demand for human labor, and also improving its productivity, wage rates as well as productivity and returns to all other factors of production.

REFERENCES

Gupta, M. L., A Case Study of Economic Potentialities of Tractor-Cultivation in Punjab (an unpublished research dissertation), Department of Economics and Sociology, PAU, Ludhiana, 1966.

Government of Haryana, Statistical Abstracts of Haryana, The Board of Economic Enquiry Haryana, Chandigarb, 1965-66 through 1969-70.

Government of Punjab, Statistical Abstracts of the Punjab, The Board of Economic Enquiry, Punjab, Chandigarb, (1954-55 through 1969-70).

Government of Punjab, Farm Accounts in the Punjab, The Board of Economic Enquiry, Punjab, Chandigarb, 1955-56 through 1967-68.

Government of India, India: Pocket Book of Economic Information, Ministry of Finance, Department of Economic Affairs, New Delhi, 1969.

Government of India, Studies in Economics of Farm Management (for various centres in India), Directorate of Economics and Statics, Ministry of Food and Agriculture, 1954-55 through 1967-68, New Delhi.

Kapoor, T. R., Optimum Cropping Patterns for IADP District, Ludhiana (unpublished dissertation), PAU, Ludhiana, 1966.

Kahlon, A. S. and S. S. Johl, "Productivity on Small Farms", The Economic Weekly, Vol. 14 (25), Bombay, 1964, pp. 985-986.

Kahlon A. S. and S. S. Johl, "Rationale of Family Farms", The Economic Weekly, Vol. 14 (16), Bombay, 1964, pp. 671-77.

Mann, K. S., An Analysis of Expected Shifts in Cropping Patterns of Punjab (India) Resulting From Introduction of High Yielding Varieties of Crops", (A Ph.D. dissertation), Ohio State University, Columbus, 1967.

Mellor, John W., The Economics of Agricultural Development, Cornell University Press, Ithaca, New York, 1966.

Mellor, John W., at. el., Developing Rural India-Plans and Practice, Cornell University Press, Ithaca, 1968.

Punjab Agricultural University, Studies in Economics of Farm Management; Ferozepur District, Punjab (Unpublished), Department of Economics and Sociology, PAU, Ludhiana, 1968-69.

Punjab Agricultural University, A Study on Utilization of Tractors on Selected Farms in Punjab (Unpublished), Department of Economics and Sociology, PAU, Ludhiana, 1969.

Shukla, Tara, Capital Formation in Indian Agriculture, Vora and Co. Publishers Ltd., New Delhi (India), 1965.

Schultz, T. W., Economic Growth and Agriculture, McGraw-Hills, New York, 1968.

Schultz, T. W., Transforming Traditional Agriculture, Yale University Press, New Haven, 1964.

Singh, Gurdev, A Study Into The Farm Adjustment Possibilities in Upper Dhaya Type of Farming Area in Ludhiana, (Unpublished research dissertation) Department of Economics and Sociology, PAU, Ludhiana (India), 1969.