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ECONOMIC OPTIMA IN RESOURCE ALLOCATION FOR THE CULTIVATORS OF KANJHAWALA BLOCK*

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INTRODUCTION

The rapid increase in population growth and the expanding demand for agricultural products together with the paucity of farm resources in India, require a careful examination of the production alternatives and the possibilities for increasing the efficiency of resource use in agriculture. In view of changing conditions of market and other factors in a developing economy, the possibilities of increasing farm returns through reorganization of the available resources and enterprises cannot be ruled out. It may however be argued that possibilities for such a reorganization are almost exhausted in the less developed economies. This popular presumption is however not true for all such regions. Even though the lack of capital resource is the main obstacle, farmers could increase their efficiency and their earnings if they could utilize more of the surplus bullock power, human labour and other resources in many regions.

Recent developments in Japan have shown that many progressive rice farmers have diversified production by growing vegetables in rotation with paddy and taken up dairy enterprise to supplement their incomes. These farmers used more labour with very little added capital. The principal increase in resource use is in more complete utilization of unpaid family labour. Possibilities of such development could be explored in some regions of India also. A scientific attempt is needed to explore the possibility of increasing farm net returns by including such enterprises as dairy, vegetables crops and improved hybrid and dwarf varieties of maize, bajra, wheat and jowar, in the farming system, which would bring higher returns and make fuller use of the surplus human and bullock labour. Such improvement would permit immediate increases in farm income and productivity of resources used on the farm.

OBJECTIVES

The rapid urban growth experienced in the vicinity of the city of Delhi and opening of new and numerous roads in the rural areas nearby, necessitate a perceptible change in the cropping patterns of the neighbouring area. There is a growing and ready demand for vegetables and milk—the two perishable commodities which can obviously be produced more advantageously in the nearby villages than those at a distance. Information based on empirical evidence is needed to determine the way in which such opportunities can be utilized under different farming situations. The present study was, therefore, undertaken to determine and outline the potential increases in farm net returns and farm labour employment by reorganization of enterprises and farm resources in the Kanjhawala Block of the Union Territory of Delhi. Capital is typically the limiting resource for these

* Kanjhawala is one of the five development blocks currently functioning in the Union Territory of Delhi.

farms; therefore, in this study the possibilities of increasing farm net returns and labour employment have been examined with restricted availability of capital and with unrestricted availability of borrowed capital to determine how returns differ with capital availability. Further, the optimal reorganization of farm resources and enterprises has been examined with and without the inclusion of vegetable crops and dairy enterprises and with and without the inclusion of improved agricultural practices under both the situations of capital availability. The specific objective of this study is to develop information which will be useful in adjusting the resource use and enterprise combination on farms in Kanjhawala Block to changing economic conditions. In view of the impact of the city of Delhi on this region, both these propositions seem to be very promising.

Sources of Data

The study was conducted in two randomly selected villages belonging to Kanjhawala Block and from a stratum of homogeneous sandy loam soil with medium salinity and water-logged conditions, which represents a particular soil-crop-complex, as obtainable on the Agronomy Farm of the Indian Agricultural Research Institute (I.A.R.I.), New Delhi. Information was obtained by survey method on the output of products, their value and the input of resources and other expense items for the two-year time period, *viz.*, 1964-65 and 1965-66. The total number of farms studied were 97 which were randomly selected from these two villages.

Methodology

The empirical method used in this study was linear programming with simplex method.[1] This technique permits simultaneous consideration of many alternatives available, to select the profit maximizing combination of activities. The mathematical structure of the model used was as follows :

$$\text{Maximize: } Z = P_1x_1 + P_2x_2 + \ldots\ldots P_nx_n$$

Subject to:

$$A_i^I = a_{i1}x_1 + a_{i2}x_2 + \ldots\ldots a_{in}x_n + A_i^T$$

$$A_i^U \geqslant a_{i1}x_1 + a_{i2}x_2 + \ldots\ldots a_{in}x_n - A_i^T$$

$$D_i^B \geqslant a_{i1}x_1 + a_{i2}x_2 + \ldots\ldots a_{in}x_n$$

$$D_i^F \geqslant a_{i1}x_1 + a_{i2}x_2 + \ldots\ldots a_{in}x_n - D_i^H$$

$$C_i \geqslant a_{i1}x_1 + a_{i2}x_2 + \ldots\ldots a_{in}x_n - C_i^B$$

$$F_i^{(Min.)} \leqslant \Sigma a_{ij}x_j$$

$$A_j^{(Max)} \geqslant a_{ij}x_j$$

$$x_{ij} \geqslant 0,\ A^T \geqslant 0,\ D^H \geqslant 0,\ C^B \geqslant 0.$$

1. For an explanation of the simplex method see Earl O. Heady and Wilfred Candler: Linear Programming Methods, Iowa State University Press, Ames, Iowa, U.S.A., 1958.

Where Z is the total net returns to fixed resources of the farm, P_j are the net returns per unit of the real activity (crop or dairy activity).

A^I and A^T are the available irrigated area and the irrigable area transferred to unirrigated crops, respectively.

A^U is the available unirrigated area.

D^B is the number of available bullock-pair days in the peak work-load period.

D^F and D^H are the number of available family labour days and hired labour days respectively during the peak work-load period.

C and C^B are the interest free capital, and borrowed capital respectively.

$F^{(Min.)}$ is the minimum food or fodder requirements.

$A_j^{(max.)}$ is the maximum area under jth activity allowed in the plan.

a_{ij} is the input-output coefficients of ith resource and jth activity where j varies from 1 to n.

The farms were classified into five groups and two farm resource situations were selected from each group of farms for programming. Input-output coefficients were worked out for ten farm resource situations representing the five groups of the farms.

The use of programming technique needed some minor refinements to suit local farming conditions in Indian agriculture. Therefore, a few of such refinements were made. For the purpose of allocation of the joint cost of farm equipment to different crops, these have been divided into three classes, namely, 'hand implements,' 'bullock or tractor drawn implements' and 'irrigation equipment.' The cost of depreciation and repairs on hand implements was allocated on the basis of human labour units used in each crop. Allocation of cost for bullock drawn implements was in proportion to bullock-pair labour days put in for different crops. Since the cost under irrigation equipment head exclusively related to the crop which received irrigation, the cost has been debited exclusively to irrigated crops on the basis of well irrigation days put in by bullocks or pumping sets on each crop.

As for allocation of work feed cost of a pair of bullocks to different crops, apportionment was made in proportion to bullock-pair days required on each crop. Similarly, tractor costs for different crops were arrived at.

The irrigated crops, particularly cash crops, required much higher doses of bullock labour[2] and capital, etc., as compared to unirrigated crops. On some farms these resources were in short supply and in some cases the irrigable area was large compared to the unirrigated area available with the farmer. Under such circumstances when programming was carried out to maximize the net returns, the optimum plans showed two kinds of results. In some cases irrigable land remained unused while unirrigated land was fully used. In some other cases where irrigable land was fully utilized, its marginal value productivity remained lower than that of the unirrigated land. These problems were overcome by

2. Bullock power could be made partly variable by including bullock-hiring or bullock-investment activity. But bullock-hiring was not practised in this region and bullock-investment involved greater risk bearing capacity because of the indivisibility of bullocks. These activities were, therefore, not included in the plan.

introducing "transfer activities"[3] into the programme. Use of transfer activities not only made possible fuller utilization of irrigable land and raised its marginal value product, but also increased the total net returns of the farm.

FINDINGS

In all, 38 optimum farm plans were prepared. These plans are shown in Tables I and II. Four plans were prepared for each of the 8 farm situations selected from the farms using bullocks for draft purposes: (*i*) with restricted capital for crops other than vegetables, (*ii*) with restricted capital for all crops, (*iii*) with unrestricted borrowed capital for crops other than vegetables and (*iv*) with unrestricted borrowed capital for all crops. For farms using tractor only, no data were available on vegetable crops, so only two plans were prepared with crops other than vegetables; one with restricted capital and the other with unrestricted borrowed capital. As regards farms using tractor plus bullocks, data on vegetables as also other crops were taken from the Agronomy Farm, I.A.R.I. and were treated as information on "improved technology" in this study. Four types of plans were prepared for farms using tractors plus bullocks; two with farmers' data (one with restricted capital and the other with unrestricted borrowed capital), and the other two with improved technology (one with restricted capital and the other with unrestricted borrowed capital).

The results of the optimum plans were studied under four heads, namely, changes in net returns of the farm, farm enterprise combination and cropping pattern, utilization of labour, and marginal productivity of resources.

Net Returns[4]

The results of the various optimum plans indicated a substantial potentiality for increasing farm net returns at proper allocation of the farm resources. Analyses of the farm net returns are shown in Tables I and II. The net returns, on an average, could increase by about 42 per cent for farms up to 10 acres, 30 per cent for farms between 10 and 30 acres and by 24 per cent for farms using

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3. A_i^T is the transfer activity which transfers some of the irrigable land (A_i^I) to the stock of unirrigable land (A_i^U) available with the farmer. It has a positive coefficient (+1) in the row of irrigable land, and a negative coefficient (−1) in the row of unirrigable land. These coefficients are the substitution rates between the activities concerned. For example, (+1) is the substitution rate between the slack activity "irrigable land" and the transfer activity, and (−1) is the substitution rate between "unirrigable land" and the "transfer activity." A positive (+1) substitution rate between A_i^T and A_i^I implies that if we bring one unit of A_i^T in the basis, our stock of A_i^I will be reduced by one unit. Similarly, a negative (—1) substitution rate between A_i^T and A_i^U implies that if we bring one unit of A_i^T in the basis, the stock of A_i^U will be increased by one unit. Thus inclusion of one unit of A_i^T causes a decrease of the stock of A_i^I and an increase of A_i^U by one unit. It is in this way that A_i^T helps in bringing together A_i^I and A_i^U.

4. Gross returns minus variable costs (expenses of seed, fertilizer, manure, depreciation and work feed cost of bullocks). Thus these are net returns accruing to land, family labour and bullock labour.

TABLE I—AVERAGE NET RETURNS PER ACRE UNDER VARIOUS PLANS

Farm size-group	Case number	Draft power	Family labour (man equivalents)	Size of holding (acres)	Percentage of area irrigable	Capital (Rs.)	Existing Plan (Rs.)	Optimum plans with farmers' data				Owned plus borrowed capital (plan with vegetables) (Rs.)
								Excluding vegetables		Including vegetables		
								Limited capital (Rs.)	Unlimited borrowed capital (Rs.)	Limited capital (Rs.)	Unlimited borrowed capital (Rs.)	
I	1	Bullocks 2	4.0	4.0	45%	360	454	702	704	998	999	363
	2	Bullocks 2	5.0	5.4	45%	550	642	700	702	1,034	1,183	740
II	1	Bullocks 2	4.0	10.0	66%	800	434	705	722	729	864	1,400
	2	Bullocks 2	4.0	10.0	20%	570	445	633	633	727	787	683
III	1	Bullocks 2	6.0	12.0	58%	100	512	658	672	689	764	1,466
	2	Bullocks 2	5.0	12.0	48%	100	516	664	679	696	753	1,450
IV	1	Bullocks 4	4.0	20.0	47%	1,800	686	719	852	789	877	3,743
	2	Bullocks 4	4.0	30.0	43%	1,600	319	534	725	557	724	5,463
V	1	Tractor 1	7.0	36.0	42%	2,700	526	553	683	—	—	5,873
	2	Tractor 1 plus bullocks 2	7.0	59.7	14%	4,470	404	560	690	571*	994*	10,042*

* With improved technology.

Note : On small farms (size-group 1 in the table), the bullock labour was in surplus in the existing plan. The dung manure obtained from the bullocks was also available in greater quantity per acre as compared to other farms. Thus the working capital used in the form of bullock feed cost, manure, etc., in the existing plan was already high and sufficient.

tractors, by reallocation of the resources with the available levels of capital while the use of unrestricted borrowed capital could increase the returns on these farms by about 50 per cent, 51 per cent and 53 per cent respectively. The average net returns which were Rs. 478, Rs. 455, and Rs. 448 per acre in the existing plan

TABLE II—TOTAL NET RETURNS PER FARM UNDER VARIOUS PLANS

(*in Rs.*)

Farm size-group	Case number	Size of holding (acres)	Existing plan	Optimum plans with farmers' data			
				Excluding vegetables		Including vegetables	
				Limited capital	Unlimited borrowed capital	Limited capital	Unlimited borrowed capital
I	1	4.0	1,814	2,808	2,815	3,993	3,996
	2	5.4	3,469	3,781	3,792	5,585	6,389
II	1	10.0	4,342	7,045	7,219	7,289	8,643
	2	10.0	4,445	6,319	3,727	7,267	7,873
III	1	12.0	6,146	7,898	8,065	8,387	9,171
	2	12.4	6,395	8,228	8,421	8,644	9,331
IV	1	20.0	13,724	14,383	17,043	15,782	17,539
	2	30.0	9,565	16,025	21,710	16,724	21,732
Tractor farms							
V	1	36.0	18,922	19,908	24,598	—	—
	2	59.7	24,031	33,442	41,034	33,926*	59,144*

* With improved technology.

for the above specified small size, medium size, and tractor farm respectively increased to Rs. 679, Rs. 625 and Rs. 557 per acre in the optimum plans with restricted capital and to Rs. 717, Rs. 687 and Rs. 686 in the optimum plans with unrestricted capital.

The relaxation of capital restriction through borrowing activity also relaxed the constraint of human labour with the help of labour hiring activity.[5] Thus

5. D_i^H is a labour hiring activity. It has a negative (−1) coefficient in the row of human labour days supply by the family (D_i^F). Inclusion of one unit of D_i^H in the basis therefore increases the stock of human labour days by one unit. It is in this way that D_i^H relaxes the labour constraint. D_i^H has a positive coefficient (equal to its wage rate) in the capital row, therefore the inclusion of one unit of D_i^H reduces the stock of capital by an amount equal to its wages. Thus the extent to which D_i^H can relax the labour constraint is dependent on the stock of capital available with the farmer. C_i^B is the capital borrowing activity with a negative coefficient (−1) in the capital row. Inclusion of this activity therefore increases the stock of capital available with the farmer and thus relaxes not only the capital constraints but also helps in further relaxing the labour constraint.

with the relaxation of labour restraint, the net returns per acre rose relatively more on larger farms where human labour was less abundant as compared to smaller farms. Increases in the net returns were obtained by including in the plan the crop rotations comprising two crops a year such as bajra-gram and jowar-gram for the unirrigated land, and Mexican wheat, sugarcane, jowar-fodder-berseem or peas, jowar-fodder-wheat, etc., for irrigated land.

Inclusion of vegetable crops in the plans along with unrestricted borrowed capital stepped up the farm net returns by 91 per cent on farms up to 10 acres in size and 71 per cent on farms between 10 and 30 acres in size. The average returns rose to about Rs. 913 per acre for the small size farms and Rs. 777 per acre for larger size farms using bullock power. The increase was comparatively less on larger farms. The reason was that vegetable crops required irrigation more frequently; and on smaller farms the available bullock labour per acre used for irrigation was greater than that on larger farms. Thus bullock power acted as the main limiting factor when restrictions of capital and human labour were relaxed by the borrowing activity. When vegetable crop rotations were included in the plans for tractor farms[6] and when improved technology[7] was applied on these farms, the net returns increased by 146 per cent with unrestricted borrowed capital. With limited capital the net returns could increase only by 41 per cent. The net returns rose from Rs. 404 per acre in the existing plan to Rs. 571 per acre in the optimum plan with restricted capital and to Rs. 994 per acre in the optimum plan with unrestricted capital. The effects of all optimum plans in increasing the net returns were found statistically significant at 1 per cent level. It demonstrates that introduction of improved technology requires larger amount of capital.

It may be noted that the possibility of increasing farm production and net returns even with the existing technology would be much more than what is shown above, if irrigation facilities were developed fully in the area in question. A careful examination of the net returns from various farm plans indicates that average farm returns have been diluted very much by the unirrigated crop rotations which occupy a large proportion of the farm land and bring net returns equal to only 20 to 40 per cent of that of the irrigated crop rotations. Among the unirrigated crop rotations there is hardly any choice; as gram being the only available *Rabi* crop which could be taken after jowar or bajra. For *Rabi* season, mustard could be the other better alternative crop but data for this crop were not available as it was not grown as a single crop in this area. The only increase in farm net returns could, therefore, be had by changing the cropping programme for irrigated land. The average net returns in the optimum farm plans including vegetable crops for the irrigated area were Rs. 1,184 and Rs. 1,382 per acre for small size farm, Rs. 888 and Rs. 1,000 for medium size farm[8] with restricted and unrestricted capital respectively. The limitation of irrigation because of high bullock use for it for vegetable crops was so serious that a portion of irrigable land remained unirrigated and it had to be occupied by unirrigated crops. The sample farms

6. Farms which used tractor plus bullock power for draft purposes.

7. Improved technology here in this study implies the data on input-output coefficient of crops grown on I.A.R.I. Agronomy Farm.

8. Small size farm refers to farms below 10 acres, and medium size farms refers to farms between 10 and 30 acres, as specified earlier in this study.

which used tractor plus bullock power had only 14 per cent of the holding as irrigable area. The diluting effect of unirrigated crop rotations on the net returns of this farm should, therefore, be kept in view while examining the influence of the optimum plan using improved technology for raising the farm net returns. The net returns of irrigated land were more than twice the average net returns per acre for the whole farm with improved technology.

Farm Enterprise Combination and Cropping Pattern

The dairy activity required high doses of capital, so it entered into the optimum plans only when the capital constraint was relaxed. The optimum size of the dairy in the plans was found to include 4 buffaloes for farms of less than 30 acres, and 8 buffaloes for larger farms. It was only with high milk-yielding buffaloes that this enterprise was found competing with crop activities under existing technology. The dairy activity could not, however, compete with crop enterprises using improved technology even with unrestricted borrowed capital.

The cropping pattern, as shown in Table III, indicated significant changes due to optimum plans. For farms up to 10 acres, the total cropped area under cash crops, which was only 8.1 per cent in the existing plan, increased to 25.7 per cent in the optimum plan with limited capital and 32.8 per cent in the plan with unlimited borrowed capital. Amongst the unirrigated crops, the area under gram increased because it could be rotated with bajra or jowar which had higher net returns than that of fallow-wheat rotation. Also the bajra-gram rotation acted as transfer activity in utilizing unused irrigable land in some cases. For farms of more than 15 acres in size, the area under cash crops also increased although not by the same order. The area under fodder crops increased and the area under food crops decreased from 76.6 per cent of the total in the existing plans to 49.1 per cent and 54.2 per cent in the optimal plans with restricted and unrestricted capital respectively. This followed the inclusion of dairy activity in the plan.

Mexican wheat crop rotation proved to be fully financially feasible in the farm plans. The Mexican wheat (Sonora 64), for which the data were available from the farmers, replaced the Indian wheats in the optimum plans even with its prices as low as two-thirds of that of Indian wheat. But since the farmers like to grow Indian wheat for their home consumption, the minimum food requirement-area restrictions retained sufficient area under the Indian varieties of wheat in the optimum plans.

On farms which used tractor plus bullocks the optimum plan with improved technology tended to reduce food crops and bring in vegetable crops into the plan. When the capital constraint was relaxed, maximum area restrictions imposed on vegetable crops began to play their part and diversify the cropping programme by including other crops such as hybrid maize and wheat.

The intensity of cropping which was below 150 per cent in the existing plans rose to about 190 to 220 per cent in the optimum plans. For larger farms the cropping intensity was relatively lower. This was so because the crop rotations which had higher intensities of cropping also required larger doses of bullock labour inputs particularly for irrigation, and on larger farms the bullock labour in relation to land was less than on smaller farms.

TABLE III—CROPPING PLANS OF TYPICAL FARM SITUATIONS FOR SANDY LOAM SOILS OF KANJHAWALA BLOCK

(area in bighas)

	5-acre farm situation with one pair of bullocks				10-acre farm situation with one pair of bullocks					20-acre farm situation with two pairs of bullocks				
	E.	N.R.	V.R.	V.U.	E.	N.R.	N.U.	V.R.	V.U.	E.	N.R.	N.U.	V.R.	V.U.
Kharif :														
Fallow..	—	—	—	3.0	14.0	—	—	—	1.0	55.0	32.5	44.0	—	32.5
Bajra (Irrigated) ..	—	11.0	—	—	—	17.0	18.0	2.0	—	—	—	—	—	—
Bajra (Unirrigated) ..	9.0	14.0	14.0	11.0	15.0	32.0	28.0	29.0	28.0	15.0	14.5	3.5	—	—
Guar (Irrigated) ..	2.0	—	—	—	1.0	—	1.0	—	3.5	—	—	—	—	3.5
Guar (Unirrigated) ..	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Jowar (Irrigated) ..	4.0	—	—	—	2.5	—	1.0	2.0	3.0	—	—	—	—	—
Jowar (Unirrigated) ..	5.0	—	—	—	12.5	—	—	—	—	20.0	53.0	52.5	53.0	53.0
Maize (Irrigated) ..	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sugarcane (Irrigated)	5.0	—	—	—	5.0	1.0	2.0	—	3.5	10.0	—	—	—	6.5
Cow-peas (Irrigated)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cow-peas (Unirrigated)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Brinjal (Irrigated) ..	—	—	3.0	7.0	—	—	—	1.0	4.5	—	—	—	3.5	3.5
Ghiya (Unirrigated)	—	—	—	—	—	—	—	—	—	—	—	—	42.0	—
Raddish (Irrigated) ..	—	—	8.0	4.0	—	—	—	16.0	6.5	—	—	—	1.5	1.0
Rabi:														
Wheat (Irrigated) ..	4.0	11.0	8.0	4.0	12.5	17.0	18.0	18.5	6.5	5.0	—	8.0	43.5	1.0
Wheat Mexican (Irrigated) ..	—	—	—	—	—	—	—	—	—	—	32.5	36.0	—	32.5
Wheat (Unirrigated)	5.0	—	—	3.0	7.5	—	—	—	1.0	45.0	—	—	—	—
Fallow (*Guar*, Jowar, Bajra, Gram) ..	—	—	—	—	10.0	—	1.0	—	3.8	5.0	—	—	—	—
Gram (Unirrigated) (Fallow)	9.0	14.0	14.0	11.0	13.0	32.0	28.0	29.0	28.0	35.0	76.5	56.0	53.0	53.0
Sugarcane (Irrigated)	5.0	—	—	—	5.0	1.0	2.0	—	3.5	10.0	—	—	—	6.5
Berseem (Irrigated) ..	—	—	—	—	—	—	—	1.0	—	—	—	—	—	3.5
Pea (Irrigated) ..	2.0	—	—	—	—	—	1.0	1.0	3.0	—	—	—	—	—
Potato (Irrigated) ..	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cauliflower (Irrigated) or cabbage.. ..	—	—	3.0	7.0	—	—	—	1.0	4.5	—	—	—	3.5	3.5
Zaid: Karela (Irrigated)	—	—	8.0	4.0	—	—	—	16.0	6.5	—	—	—	1.5	1.0
Tomatoes (Irrigated)	—	—	—	—	—	—	—	—	—	—	—	—	—	—

(Contd.)

TABLE III—CROPPING PLANS OF TYPICAL FARM SITUATIONS FOR SANDY LOAM SOILS OF KANJHAWALA BLOCK—(*Concluded*)

(*area in bighas*)

	30-acre farm situation with two pairs of bullocks					60-acre farm situation with one pair of bullocks and one tractor			
	E.	N.R.	N.U.	V.R.	V.U.	E.	N.R.	V.R.	V.U.
Kharif :									
Fallow	74.0	15.0	32.0	27.0	31.0	180.0	44.0	172.0	—
Bajra (Irrigated)	—	—	—	—	—	—	—	—	—
Bajra (Unirrigated) ..	30.0	86.0	—	85.0	—	40.0	256.0	—	—
Guar (Irrigated)	10.0	—	11.0	—	11.0	12.0	—	—	—
Guar (Unirrigated) ..	—	—	—	—	—	8.0	—	—	—
Jowar (Irrigated)	—	—	—	—	—	—	—	6.0	7.0
Jowar (Unirrigated) ..	30.0	49.0	85.0	—	85.0	50.0	—	58.0	122.0
Maize (Irrigated)	—	—	—	—	—	—	—	—	24.0
Sugarcane (Irrigated) ..	6.0	—	22.0	—	23.0	30.0	—	—	—
Cow-peas (Irrigated) ..	—	—	—	—	—	—	—	6.0	7.0
Cow-peas (Unirrigated)	—	—	—	—	—	—	—	28.0	—
Brinjal (Irrigated) ..	—	—	—	—	—	—	—	—	—
Ghiya (Unirrigated) ..	—	—	—	38.0	—	—	—	—	—
Raddish (Irrigated) ..	—	—	—	—	—	—	—	—	—
Rabi :									
Wheat (Irrigated) ..	20.0	—	1.0	38.0	31.0	14.0	44.0	32.0	20.0
Wheat Mexican (Irrigated)	—	15.0	31.0	—	—	—	—	—	—
Wheat (Unirrigated) ..	20.0	—	—	—	—	114.0	—	—	—
Fallow (*Guar*, Jowar Bajra, Gram)	24.0	49.0	—	27.0	11.0	62.0	—	140.0	—
Gram (Unirrigated)(Fallow)	80.0	86.0	85.0	85.0	85.0	80.0	256.0	116.0	256.0
Sugarcane (Irrigated)	8.0	—	22.0	—	23.0	30.0	—	—	—
Berseem (Irrigated) ...	—	—	—	—	—	—	—	—	—
Pea (Irrigated)	—	—	—	—	—	—	—	—	—
Potato (Irrigated)	—	—	—	—	—	—	—	—	12·0
Cauliflower (Irrigated) or cabbage ..	—	—	—	—	—	—	—	12.0	12.0
Zaid : Karela (Irrigated) ..	—	—	—	—	—	—	—	—	15.0
Tomatoes (Irrigated) ..	—	—	—	—	—	—	—	12.0	12.0

E. = Existing crop plans.
N.R. = Non-vegetable optimum plan with restricted capital.
N.U. = Non-vegetable optimum plan with unrestricted capital.
V.R. = Optimum plan including vegetable crops with restricted capital.
V.U. = Optimum plan including vegetable crops with unrestricted capital.
One acre = 5 *bighas*.

Note : On a 30-acre farm, two pairs of bullocks were insufficient so much so that a part of the irrigable land remained in disposal in the plan when capital was restricted and transfer activities were not included. Crops which required higher doses of bullock labour such as vegetable crops could not enter into the plan due to lack of bullock labour even after relaxing capital through borrowing activities.

Utilization of Labour[9]

The optimum plans provided better opportunities for labour utilization in all the periods. The increase in labour employment resulted from the inclusion of vegetable crops in the optimum plans, which required much higher doses of labour. The increase in the utilization of labour was relatively more in October-November and April-May than in other periods, though it increased in all periods. The optimum plans with unrestricted borrowed capital, on an average, provided better opportunities of employment as compared to those with restricted capital; with the use of improved agricultural practices the utilization of labour improved further. The increase in labour utilization was found statistically significant at 1 per cent level.

The average utilization of labour increased from 45 man-days per month in the existing plans to 68.6 and 92.3 man-days per month in the optimum plans with restricted and unrestricted borrowed capital respectively for farms using bullock power with holdings below 15 acres. For larger farms extending over 35 acres which used tractor power, the labour utilization rose from an average of 200 man-days per month in the existing plan to 269 man-days per month in the optimum plan with restricted capital, and to 291 man-days per month in the optimum plan with improved agricultural practices and borrowed capital.[10]

Considering the per acre average utilization of labour, the utilization of labour per month per acre increased from 3.5 man-days in the existing plan to 5.2 man-days in the plan with restricted capital and 7.1 man-days in the plan with unrestricted borrowed capital for farms using bullock power only. On tractor farm the per acre utilization of labour increased from the existing level of 4.2 man-days to 5.7 man-days per month in the plan with restricted capital and 6.3 man-days per month with improved agricultural practices and unrestricted borrowed capital.

The use of hired labour increased considerably in the optimum plans. On farms above 15 acres in size and using bullock labour, the use of hired labour during October-November increased from zero in the existing plan to 52 and 132 man-days in the plans with restricted capital and unrestricted borrowed capital respectively. In April, the use of hired labour increased from 52 man-days in the existing plan to 117 man-days in the plan with borrowed capital. For farms using tractor plus bullocks, the use of hired labour in April increased from an existing level of 27 man-days to 112 man-days in the optimum plan with borrowed capital and to 218 man-days in the plan with improved agricultural practices and unrestricted borrowed capital.

The optimum plans also provided fuller utilization of bullocks. In case of farms up to 10 acres in size, the average utilization of bullocks in peak seasons rose from an existing level of 11.5 pair-days per month to 17.7 and 21.2 pair-days per month in the plans with restricted and unrestricted capital respectively. On farms of 10-15 acres in size the corresponding figures were 21.1, 23.8 and 26.9 pair-days. For farms above 15 acres in size, the utilization of bullocks per month increased from 36.4 pair-days in the existing plan to 41.1 and 47 pair-

9. "Labour" includes both family and hired labour.
10. It was assumed that hired labour was available to the extent required.

days in the optimum plans with restricted capital and unrestricted borrowed capital respectively.

Marginal Value Productivity of Resources

The marginal value product of land varied considerably from farm to farm depending upon the availability of other resources. In the optimum plans with restricted capital, the marginal value product of an acre of land varied from zero to Rs. 911.2 for irrigable land and from Rs. 155 to Rs. 508.1 for unirrigated land. In four of the ten farm situations programmed, the marginal value product of irrigable land was zero, *i.e.*, a part of the irrigable land remained unused because the available quantity of labour and capital per unit of irrigable land was much lower in these farms than that on others; and the high net return crops, such as vegetable crops, used higher doses of labour and capital. The marginal value products of capital and labour were found to be much higher in these four cases than in others. With the relaxation of the capital restraint, hired labour and capital became available in required quantities, and the marginal value product of land increased. It then varied from Rs. 61 to Rs. 2,383.5 per acre for irrigable land, and from Rs. 268.5 to Rs. 1,126.5 per acre for unirrigated land, and no land remained unused.

The marginal value product of capital varied from Rs. 3.48 to Rs. 7.08 per rupee (for a crop season of 6 months) in the optimum plans with restricted capital. After the capital borrowing activity was included, capital continued to be borrowed and used in all the plans until its marginal value product[11] dropped to Rs. 1.06 (*i.e.*, principal plus interest for 6 months) per rupee in the plans with unrestricted borrowed capital.

The marginal value product of human labour was higher on farms which were larger than 15 acres in size and which used bullock power for draft purposes. The marginal value product of labour decreased with the use of borrowed capital, though it still remained higher than the wage rate. On farms below 15 acres in size, the available family labour remained surplus, though the extent of its utilization increased in the optimum plans and particularly when capital was borrowed; the marginal product of labour on these farms remained zero and no hiring of labour was needed except on a farm of ten acres where labour hiring was needed in the October-November period and that only when the capital constraint was relaxed through borrowing activity.

As regards marginal value product of bullock labour, it increased with the relaxation of capital restraint. This happened because vegetable crops and other crops using bullock labour more intensively and giving higher returns entered into the plan, when capital borrowing was introduced. Since bullock labour was not hired, the inclusion of higher return activities in the plan resulted in an increase in the marginal value product of bullock labour. As the ratio of bullock labour to land (particularly irrigated land) varied from farm to farm, the consequent variation in the marginal value product of bullock labour was

11. In the model, the net marginal value products of resources were obtained; for this paper these were then converted to gross values by adding to it the per unit variable cost of the resource. In the case of land the cost was treated zero. For family labour also the cost was zero, but for hired labour, the variable cost was equal to its wages.

expected. For example, in October-November for plans with restricted capital, the bullock labour was in surplus and its marginal product was zero on 5 of the 8 farm situations; on the other farms the marginal product ranged from Rs. 3.30 to Rs. 81.24 per day per pair of bullocks. When the capital constraint was relaxed and vegetable crops entered into the plan, bullock labour did not remain surplus on any farm and the marginal product of the bullock labour ranged from Rs. 56.86 to Rs. 95.93 per pair per day. As regards April-May, on 6 of the 8 farm situations in which bullock labour was not in surplus, the marginal product of bullock labour ranged from Rs. 10.64 to Rs. 60.24 per pair per day in plans with restricted capital and from Rs. 35.83 to Rs. 76.30 per pair per day in plans with unrestricted borrowed capital.