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also under-utilized at the existing use pattern. The main reason for the under-utilization of the available bullock and tractor power is the existence of numerous small, scattered and independent operational holdings in the State. Secondly, the out of pocket expenses to be incurred for performing various agricultural operations through the bullock power are much lower than that of the tractor power. At the existing use pattern, it is much cheaper to cultivate one hectare of land on typical farms in the State by using the bullock power. This shows that under the existing farming conditions in the State, the bullock power is more economical and preferable over the tractor power for the majority of the farmers.

FARM TRACTORISATION—A BENEFIT-COST ANALYSIS

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Introduction

In India the use of tractor has so far been confined to only a limited farm operations subject to certain structural as well as economic problems. But in recent times farmers are becoming more capital investment conscious and entail risk as entrepreneurs for putting into practice more and more farm machineries. For attaining a technological change, first of all the system of cultivation has to be assimilated to modern needs and secondly, the farm conditions as such are least favourable for the widespread utilization of such machineries. Technological change in agriculture consists of adoption of farming techniques developed through research and calculated to bring about diversification and increase of production and greater economic return to the farmer.[1] But our conditions are such that with the evolution of tractor we have been able to mechanize only a certain isolated farm operations. However, as stated above, it helped to bring out an increase in the general level of production, extensive as well as intensive utilization of land. Moreover, tractorisation resulted in the widespread use of high-yielding varieties and increased use of fertilizers.

Objective

The major underlying factor for introducing tractor is the requirement of huge investment. In such situations it is advisable to see the profitability of such an investment which otherwise would have been used for other inputs which have got direct impact on productivity. But the new technology has enabled to improve the farm conditions to a greater extent. The introduc-

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1. V. G. Panse, "Promotion and Assessment of Technological Changes in Indian Agriculture," *Indian Journal of Agricultural Economics*, Vol. XXI, No. 1, January-March, 1966, p. 120.

tion of tractor has accompanied changes in farm technology and size of the farms.[2] This paper throws light on the income generating activities of two farm situations, *viz.*, tractor technology and bullock technology and to assess the profitability obtained through tractorisation. Hence, this paper is mainly confined to two major aspects: (*i*) private benefit-cost analysis of tractor technology and bullock technology at the existing farm situation; (*ii*) the profitability of replacing bullock technology with tractor technology and the benefit accrued from there.

In order to assimilate this information a sample of 50 farms comprised of 25 tractor owned farms and 25 bullock farms were selected. The data have been collected from Anand taluka of Gujarat State. For the selection of tractor farms, the villages of the taluka were stratified into three groups, *viz.*, villages having 1 to 5 tractors, 5 to 10 tractors and more than 10 tractors. A random sample of five, six and fourteen farms was selected from each group based on the village population of tractors in each group. Due to the non-availability of pure bullock farms (farms not using tractor at all during this period), a sample of 25 bullock farms was selected on the basis of least number of tractor hours used. The data pertained to the agricultural year 1972-73.

The selected samples were having a homogeneous structure of land utilization, cropping pattern, irrigation potential and investment pattern. We have made six major assumption as follows:

1. The assumed technologies, *viz.*, tractor technology and bullock technology represent the sample tractor and bullock farms respectively with the following assumptions:

(*i*) The cropping pattern and cropping intensity in both the technologies were the corresponding average cropping pattern and average cropping intensity on respective farms.

(*ii*) Investment made on land, irrigation resources and farm implements in both the technologies were the corresponding average investments on respective farms.

(*iii*) The value of crop output and cash expenditure in different technologies were respectively the average value of crop production and expenditure on respective farms.

2. The life span of tractor and implements, bullock and implements was assumed as 10 years and 5 years respectively. It was also assumed that the economic life of the above would not change during this period of time and no major replacement is done in the case of tractors.

2. E. L. Burger, *et al:* Tractors and Their Power Units, Second Edition, Wiley Eastern Pvt. Ltd., New Delhi, 1967, p. 11.

3. The incomes from crop production, sale of water and custom hiring were the only sources of income in both the technologies and the custom hiring out activity was not applicable to the bullock technology.

4. The input-mix was assumed to remain constant in both the technologies.

5. The rental value of land was assumed at 10 per cent of the land value and the rate of interest (r) was taken at 12 per cent.

6. In order to find the benefit-cost ratio by the replacement of bullock technology with tractor technology we have assumed that one tractor sample equals two bullock samples in size.

Models Used for the Present Value Analysis

1. *Net profit/loss at the existing farm situation :*

$$NPL_{jn} = \sum_{t=1}^{10} A_{jn}/(1+r)^t - [(TI)_j + (BI)_j + (II)_j + (BI)_j (1+r)^5]$$

where
NPL_{jn} is the net profit/loss resulting at the nth level of custom hiring out (custom service) in the jth farm.

j = 1, 2 : tractor farm size, bullock farm size,
n = 1, 2 : without custom service, with custom service,
A_{jn} = contribution at the nth level of custom service in the jth farm size, and $(TI)_j$, $(BI)_j$, $(II)_j$ are investments on tractor, bullock and irrigation resources respectively in the jth farm size.

2. *Benefit-cost ratio:*

$$(BCR)_{jn} = \sum_{t=1}^{10} A_{jn}/(1+r)^t \, [(TI)_j + (BI)_j + (II)_j + (BI)_j/(1+r)^5]$$

where $(BCR)_{jn}$ is the benefit-cost ratio.

3. *Profit/loss resulting by the replacement of bullock technology with tractor technology:*

$$(NEPR)_n = P_1 - (X + Y + Z)$$

where $(NEPR)_n$ is the net profit/loss resulted by the replacement of bullock technology with tractor technology.

$$P_1 = \sum_{t=1}^{10} (A_{1n} - 2A_{2n}) / (1+r)^{10}$$

$$X = (TI)_1$$
$$Y = (BI)_1 - 2\,(BI)_2$$
$$Z = Y / (1 + r)^5$$

4. *Benefit-cost ratio by the replacement of bullock technology with tractor technology:*

$$(BERBT)_n = P_I / (X + Y + Z)$$

where $(BERBT)_n$ is the benefit-cost ratio.

Crop Activity

The pattern of crop activity in both the technologies remained more or less similar except the domination of cash crops in tractor technology as against the concentration of bullock technology on food crops. The details are exhibited in Appendix 1. In tractor technology about 60 per cent of the gross cropped area was shared by the cash crops such as tobacco and cotton, while in bullock technology it was below 50 per cent. The cropping intensities were 122.3 per cent and 116.1 per cent in the respective technologies. But it does not give a clear picture of the seasonal utilization of land and when we consider the high potential of irrigation facilities the above figures of cropping intensities were too low. Hence in this context we have to consider the area occupied by two season crops such as tobacco and cotton. So we have found out the seasonal index which is about 158 per cent and 151 per cent respectively for the tractor and bullock technologies.

Cost of Production, Crop Output and Employment

In tractor technology the production cost per hectare was found higher compared to bullock technology irrespective of all crops, except for wheat (Appendix 2). The gross output as well as net output per hectare was comparatively higher in tractor technology for all the selected crops. Even with a higher cost of production the net output figure shows that tractorisation has responded positively in bringing out a higher level of output. But the bullock technology was found profitable only when comparing the level of input use with the corresponding output level and in this regard land is the predominant factor. In general we can conclude that the introduction of tractor has increased the use of more inputs and enabled to attain an expanded output.

As we mentioned earlier, tractors are used mainly for preliminary tillage operations and hence the view about the possibility of replacement of labour was not conflicting. It has to be noted that not every type of mechanization leads to displacement of labour. Tractor, in fact, may be important in raising yield and creating additional demand for labour under this condition. In bullock technology the employment per hectare was considerably higher for crops such as paddy and wheat. Barring this, there was not any significant displacement of human labour on per hectare basis through tractorisation.

Present Value of Investment

In tractor technology, the investment structure was dominated by the investment on tractor and implements, and it accounted for over 75 per cent of the total investment (Table I). The next item of investment in tractor technology in order of importance was irrigation resources which accounted for about 20 per cent of the total. In bullock technology, the investment made on bullock and implements was predominant followed by the investment on irrigation resources. The present value of investment per hectare on the tractor technology was as large as seven times compared to the bullock technology.

TABLE I—PRESENT VALUE OF INVESTMENT IN TRACTOR TECHNOLOGY AND BULLOCK TECHNOLOGY

(*Rupees*)

Particulars	Tractor technology		Bullock technology		Column (4) as per cent to column (2)
	Present value of total investment	Per hectare value of total investment	Present value of total investment	Per hectare value of total investment	
	(1)	(2)	(3)	(4)	(5)
Investment on					
(1) Irrigation resources	9,350 (19·9)	1,320	1,010 (29·4)	289	21·9
(2) (*i*) Tractor	26,750 (57·0)	3,778	—	—	—
(*ii*) Implements	8,880 (18.9)	1,254	—	—	—
Sub-total:	35,630 (75·9)	5,032	—	—	—
(3) (*i*) Bullocks	1,031 (2·2)	146	1,442 (42·0)	413	282·9
(*ii*) Implements	920 (2·0)	130	982 (28·6)	281	216·2
Sub-total:	1,951 (4·2)	276	2,424 (70·6)	694	251·4
Total (1)	46,931 (100·0)	6,628	3,434 (100·0)	983	14·8
Present value of the reinvestment on bullock and implements	1,100	155	1,380	395	254·8
Total (2)	48,031	6,784	4,814	1,379	20·3

Relative Contribution of the Two Technologies

The income generating activities of tractor technology were crop production, sale of water and hiring out (custom service) of tractor, and for bullock technology hiring out activity was not applicable. Custom service was one of the major sources of income in tractor technology and it accounted for about 20 per cent of the total income (Table II). In bullock technology crop production was the only source of income since income through sale of water was negligible. For arriving at the net contribution, rental value was taken as 10 per cent of land value. The net contribution was positive in tractor technology with and without custom services. In tractor technology the net contribution accounted for over Rs. 17,500 with custom service as against Rs. —1,296 in bullock technology.

TABLE II—CONTRIBUTION IN TRACTOR AND BULLOCK TECHNOLOGIES

(*Rupees*)

	Tractor technology	Bullock technology
Income from		
(*i*) Crop production (I_1)	39,031	15,261
(*ii*) Sale of water (I_2)	3,110	193
(*iii*) Custom services (I_3)	11,822	—
Total income (I)	53,963	15,454
Cost of cultivation (C)	15,121	6,250
Rental value (R)	21,200	10,500
Net farm income (I_1—C)	23,910	9,011
Net contribution		
(*i*) Without custom services (I_1+I_2)—(C+R)	5,820	—1,296
(*ii*) With custom services I—(C+R)	17,642	—1,296

Present Value of Contribution

The present value of contribution in tractor technology was positive in both with and without custom service but was negative in bullock technology (Table III). It has to be noted that the role of custom services was important in the net present value of contribution in tractor technology because the net present value of contribution was negative without custom services. So it is evident that the return on the huge investment made on the tractor was not profitable through own farm activity. In bullock technology the net present value of contribution was too low and it was about Rs. —15,023. The benefit-cost ratio was positive in tractor technology with and without custom service and it was 0.63 and 1.98 respectively against —2.87 in bullock technology. So we can conclude that custom service activity was one of the deciding factors of profitability through tractorisation.

TABLE III—NET PRESENT VALUE OF CONTRIBUTION

(*Rupees*)

	Tractor technology	Bullock technology
Present value of contribution		
(*i*) Without custom services	33,152	—10,213
(*ii*) With custom services	98,413	—10,213
Present value of investment	48,031	4,810
Net present value of contribution		
(*i*) Without custom services	—14,879	—15,023
(*ii*) With custom services	50,386	—15,023
Benefit-cost ratio		
(*i*) Without custom services	0·63	—2·87
(*ii*) With custom services	1·89	—2·87
Net profit/loss resulting from the replacement of bullock technology with tractor technology	Net profit/loss	Benefit-cost ratio
(*i*) Without custom services	18,507	1·63
(*ii*) With custom services	92,560	3·87

Replacement of Bullock Technology with Tractor Technology

So far we have discussed the economics of tractor and bullock technologies at the existing farm situations. In order to find the net profit or loss accrued through the replacement of bullock technology with tractor technology one tractor farm was compared with two bullock farms. The profit resulted through the replacement was Rs. 18,507 and Rs. 92,560 respectively for without and with custom services. The benefit-cost ratio obtained was high on both the situations and it was 1.63 and 3.87. The benefit-cost ratios thus obtained were higher than the existing farm situations on both with and without custom services.

Conclusion

To arrive at a meaningful conclusion on how tractorisation resulted in a greater return to investment, it is feasible to work out the productivity of tractor influenced by other available resources. The investment on tractor ties up the funds over a period of time and applying the opportunity cost principle by comparing the returns from the tractor with other inputs at the initial stage of tractorisation, we cannot arrive at a satisfactory conclusion. The major objectives in our planning and policies are to expand the

gross output substantially to meet the increased demand and hence there is no question of equating the investment on tractor with alternative income opportunities.

In our benefit-cost analysis we found that the tractor technology contributed a higher net return compared with the bullock technology at the existing farm situation. Custom service was one of the major source of income generating activity in tractor technology and it can be supported by the fact that with limited farm size, huge investment cannot yield a profitable net return through crop production alone. Since tractors are mainly involved in preliminary tillage operations the question of displacement of labour does not arise at all and hence there is no reduction in labour input in tractor technology. The benefit-cost ratio in tractor technology was positive with and without custom services as against the negative benefit-cost ratio in bullock technology. The replacement of bullock technology with tractor technology was found profitable even without custom service. Thus tractorisation helped the increased use of inputs, more employment opportunity through extensive as well as intensive utilization of land, expanded output and maximum net return.

APPENDIX 1

Cropping Pattern and Cropping Intensity

(hectares)

Cropping pattern	Tractor technology	Per cent to gross cropped area	Bullock technology	Per cent to gross cropped area
Tobacco	3·95	45·62	1·31	30·73
Cotton	1·42	16·41	0·76	17·80
Paddy	0·71	8·27	0·42	9·82
Bajra	1·63	18·81	1·15	26·97
Wheat	0·60	6·93	0·44	10·32
Gross cropped area	8·66	100·00*	4·05	100·00
Net operational area	7·08	—	3·49	—
Cropping intensity	122·32	—	116·05	—
Seasonal index	158·02**		151·85	—

* Minor crops are not included.

** Seasonal Index $= \frac{\Sigma A_i X_i}{\Sigma X_i}$

where A_i is the seasonal unit of the ith crop (seasonal unit for tobacco and cotton is taken as two and for other crops as one) and X_i the area under the ith crop.

APPENDIX 2

COST OF PRODUCTION, HUMAN EMPLOYMENT, GROSS OUTPUT AND NET OUTPUT PER HECTARE IN BOTH TECHNOLOGIES

Crops	Cost of production per hectare (Rs.)			Employment per hectare (man-days)		
	Tractor technology	Bullock technology	Column (2) as per cent to col. (1)	Tractor technology	Bullock technology	Column (5) as per cent to col. (4)
	(1)	(2)	(3)	(4)	(5)	(6)
1. Tobacco ..	2,122	1,637	77·1	163	179	109·8
2. Cotton ..	2,604	2,141	82·2	217	203	93·5
3. Paddy ..	1,489	1,148	77·1	81	131	161·7
4. Bajra ..	961	623	64·8	72	66	91·7
5. Wheat ..	1,191	1,201	100·8	81	112	138·3

Crop	Gross output per hectare (Rs.)			Net output per hectare (Rs.)		
	Tractor technology	Bullock technology	Column (8) as per cent to col. (7)	Tractor technology	Bullock technology	Column (11) as per cent to col. (10)
	(7)	(8)	(9)	(10)	(11)	(12)
1. Tobacco ..	5,280	4,046	76·6	3,158	2,409	76·3
2. Cotton ..	5,760	5,146	83·3	3,156	3,005	95·2
3. Paddy ..	3,056	2,671	87·4	1,567	1,523	97·2
4. Bajra ..	2,412	1,934	80·2	1,451	1,311	90·4
5. Wheat ..	2,715	1,960	72·2	1,524	759	49·8

ECONOMICS OF DIESEL AND ELECTRIC TUBE-WELLS IN NAINITAL TARAI, UTTAR PRADESH*

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Introduction

The recent advances in Indian agriculture have made the farmers realise that irrigation is an important farm input for raising crop productivity and ultimately the farm income. Irrigation has become all the more important for growing high-yielding varieties of crops and using enough fertilizer. Although Tarai region of Nainital district receives an annual average rainfall

*This paper is based on the Report on Water Management and Crop Water Use in Nainital Tarai Vol. IV, an I.C.A.R. Integrated Project on Water Management and Soil Salinity (1973-74 and 1974-75), Experiment Station, G. B. Pant University of Agriculture and Technology, Pantnagar, Nainital. T. V. Moorti was associated in the project at Pantnagar, as Irrigation Economist.

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