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Variations in Agricultural Productivity

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Despite the share of agriculture sector in the national income is gradually declining with the progress of industrialisation it continues to be of vital importance for feeding and growing population of the world. Increases in output in this sector depend primarily on enhancing the productivity of labour and land. However, the levels of labour and land productivity, which in turn influence the rates of growth, vary substantially from region to region and even in the same region at different periods. Therefore, the study of extent and factors of regional variations in agricultural productivity needs no emphasis.

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The present paper attempts to examine the extent and sources of regional variations in agricultural productivity in Karnataka State. Districts are considered as 'regions' for the present work. The study is conducted for the periods 1960-61, 1970-71 and 1975-76 and covers all the 19 districts of Karnataka state.

Regional Disparity in Agricultural Productivity in Karnataka

The connotation of the word "Agriculture" is a comprehensive one and includes crop production together with land & water Management, animal husbandry, fishery and forestry".[1] We exclude fishery and forestry from the above definition to describe agriculture for our purpose. And agricultural output of each district refers to Net District Domestic Product (NDDP) contributed by agricultural sector to District Income.

Variations in agricultural productivity among the districts can be measured either in terms of product per worker engaged in agriculture or product per hectare of area brought under cultivation. Our measure of agricultural productivity is product per worker engaged in agriculture. To find out the product per worker engaged in Agriculture (hereafter called simply agricultural productivity) in each district, we have divided Net District Domestic Product originating from agricultural sector by respective district's workers (Cultivators+Agri-

1. *See* : *The Report of the National Commission on Agriculture*, Ministry of Agriculture and Irrigation, Government of India, 1976, Pt. I, P. 12.

cultural labourers) engaged in agriculture. Labour productivity thus calculated at constant prices for 1960-61, 1970-71 and 1975-76 for each of the districts of Karnataka are presented in Table-1.

Table 1

Variations in Agricultural Labour Productivity in Karnataka: 1960-61, 1970-71 and 1975-76

(At 1960-61 Prices)

Sr. No.	District	Labour Productivity in Agriculture (In Rs.)		
		1960-61	1970-71	1975-76
1.	Kodagu	3254	4204	4387
2.	Shimoga	1753	1469	1448
3.	U.K.	1705	1221	1246
4.	Chikmagalur	1598	2374	1893
5.	D.K.	851	970	1122
6.	Bellary	579	932	716
7.	Hassan	850	999	1093
8.	Tumkur	725	652	905
9.	Chitradurga	444	757	885
10.	Belgaum	612	620	679
11.	Mysore	560	966	1075
12.	Mandya	637	834	1065
13.	Dharwad	510	617	612
14.	Bangalore	477	596	645
15.	Kolar	438	534	628
16.	Raichur	444	960	710
17.	Gulburga	461	798	596
18.	Bijapur	362	517	550
19.	Bidar	423	676	781
	Karnataka	687	854	880

Source: Calculated from :

(i) Net State Domestic Product of Karnataka at factor cost by industry of origin, 1960-61, 1970-71, 1975-76, Bureau of Economics and Statistics, Govt. of Karnataka, Bangalore.

(ii) Population Census, Publications.

(iii) Our estimates.

It is clear, from the table, that, there are wide variations in the levels of labour productivity among the districts of Karnataka in all the periods. It varies all the way from the maximum of Rs. 3254 in Kodagu to the minimum of Rs. 362 in Bijapur in sixties. Only in 7 districts the productivity is found to be higher than the State average in 1960-61. Even in 1970-71 and 1975-76 the highest and lowest labour productivity districts are Kodagu & Bijapur respectively. It is revealed from the table that there are still 50% of the districts which experience labour lower than state average in 1970-71 and 1975-76. To know the extent of inter-district variations in output per worker employed in agriculture, we have calculated the coefficient of variation (C.V.) of the same. It turns out to be 78.87%, 77.49% and 76.02% for 1960-61, 1970-71 and 1975-76 respectively. It only suggests that, there is a marginal reduction in regional inequalities in agricultural productivity as measured in terms of product per worker.

Another striking observation emerging from the data shown in the table is that, although the average productivity per worker engaged in agriculture has changed from Rs. 687 in 1960-61 to Rs. 880 in 1975-76, there is remarkable stability in the rank order of districts with respect to labour productivity between 1960-61 and 1975-76. To show this stability the rank correlation coefficient is worked out for the labour productivity in 1960-61 and 1970-71, 1960-61 and 1975-76. It is +.78 and +.82 between 1960-61 and 1970-71, and between 1960-61 and 1975-76 respectively. This indicates that the ranks of districts are almost identical between 1960-61 and 1975-76. However, there might be few shifts, but are not much significant as compared with the overall pattern of stability. It implies that the districts which are agriculturally backward in 1960-61 continue to remain in the same position even after 20 years of planning. To remove these imbalances, it is necessary to identify the factors of variations in agricultural productivity.

Sources of Variations in Agricultural Productivity

The productivity differences in agriculture can be ascribed to innumerable factors which are natural, economic, technological, social and institutional in character and are mutually reinforcing. Based on the above hypothesis, we propose to consider a wide range of factors, namely, (1) Man-land ratio; (2) Cropping intensity; (3) Cropping pattern; (4) rainfall; (5) irrigation (6) size of holding; (7) concentration ratio; (8) draught animals; (9) tractors: (10) pumpsets; (11) Agricultural implements; (12) Chemical fertilizer; (13) HYV area; (14) rural literacy rate; (15) infrastructure facilities; as sources of variations in agricultural productivity in Karnataka State. In fact some of the above factors are considered as sources of variations in agricultural productivity by several writers[2] in their works.

Specifications of variables and Data Base

In all 15 variables are selected for the present work. 1. Cropping intensity-X_1; (2) area under cash crops as proportion of GLA-X_2; (3) number of tractors per 'Lakh-hectare' unit of NSA-X_3; (4) area under High Yielding Varieties of food crops as a proportion of corresponding total Cropped area (1971 and 1975)-X_4; (5) Index of infrastructure for agriculture-X_5. Roads, rural electrification, credit institutions, veterinary institutes, regulated markets and degree of urbanisation are the items included in preparing the index of infrastructure for agriculture (6) draught-animals per '100-hectare "unit of NSA-X_6 (7) number of pumpsets per '100-hectare' unit of gross irrigated area-x_7; (8) fertilizer consumption per hectare of GCA (kg)-X_8; (9) rural literacy rate (Excluding 0-4 population)-X_9; (10) normal rainfall (M.M.)-X_{10}; (11) Average size of holding-X_{11}; (12) concentration ratio[3]-X_{12}; (13) man-land ratio-X_{13}; (14) irrigated area as proportion of NSA-x_{14}; (15) Agricultural implements per '100-hectare' unit of NSAx_{15}.

The relevant data in respect of above factors are obtained from several published and unpublished reports and are presented in Appendix Table-1. However, while reading the results of our analysis, it is necessary to remember some of the limitations of the data used in the present study. Some variables are in flow term and some are in stock. The data on cropping intensity. 3 Formula for calculating concentration ratio is as follows:

$$CR = \frac{500 - \frac{1}{2}\sum_{i=1}^{n}(q_{i-1})\, r_i}{5000}$$

where, q_i is cumulative percentage of area under size group i, and r_i is percentage of holdings in size group i. cropping pattern, irrigation, fertilizer consumption and area under HYV are based on annual reports. Whereas data on agricultural workers, tractors, agricultural implements, draught animals, pumpsets etc. are in Stock terms. Instead of taking the actual education and Skill level of farm workers, we have taken the effective rural literacy rate as a proxy for education status of farm workers. In case of tractors, we have used only the number of tractors rather than data by size and type. We have also not made any distinction of the sources of irrigation. Most of the weaknesses in our data are due to non-availability of relevant data for each district and for each period under consideration. However, the use of available data and the models employed in the present study seems to provide the right indicators of the problems of Karnataka State.

Coefficient of Determination between Labour Productivity: in Agriculture and Selected variables

We hypothesize that the inter-regional variations in labour productivity is largely explained by the factors like, Cropping intensity, area under cash crops, tractors,

2. For example: (1) Y. Hayami and Ruttan, "Agricultural Productivity differences among countries," *American Economic Review*, Vol. LX, 5, Dec. 1970, pp. 894-911. (2) P. K. Joshi and T. Haque, "An Enquiry into the long-term prospects of balanced agricultural growth in India", *Indian Journal of Agricultural Economics*, Vol. 35, No. 4, Oct.-Nov. 1980, pp. 1-8. (3) M. S. Bhatia, "State-wise variations in growth of food production in India", *Agricultural Situation in India*, Aug. 1981, pp. 379-384, (4) P. S. Sharma, "Impact of Selected aspects of labour and land on per acre productivity", *Indian Journal of Agricultural Economics*, Vol. 21, 1, Jan.-March 1966, pp. 31-41. (5) A. Vaidyanathan, "Labour use in Indian Agriculture-An Analysis based on farm-management study data", In ILO-ARTEP publication, Nov. 1978, p. 44. (6) M.M. Dadi: "Occupational Structure and Productivity Levels in the Districts of Gujarat" a paper presented at the 2nd GEC held at Baroda on 2-3 Jan. 1971. (7) G. S. Bhalla and Y. K. Alagh", *Performance of Indian Agriculture—A District-wise study*',, Sterling Publishers, Pvt. Ltd., New Delhi, 1979, p. 196. (8) R. S. Bhawa and Parmindar Singh", sources of Inter-district Variations in Agricultural Productivity in Punjab", *PSE Economic analyst*, Vol. II, Dec. 1980, pp. 38-46.

HYV area, infrastructure, draught animals, pumpsets, fertilizer use, literacy rate, annual rainfall, average size of holding, concentration ratio, man-land ratio, irrigation and agricultural implements in Karnataka. In other words, labour productivity is expected to be positively associated with each of the variables except man-land ratio. Man-land ratio is expected to be negatively associated with labour productivity. To know the extent to which each of the variables, individually, explains the productivity differentials, we have worked out the coefficient of determination (i.e. R^2) between labour productivity and each of the variables. For this purpose we have used Cross-section data for the period 1975-76.

From the Table-2, it is clear that only 3 factors are significantly correlated with labour productivity with expected signs. 32%, 36% and 51% of inter-district variations in agricultural labour exproductivity is explained by area under cash crops, literacy rate and concentration ratio respectively during the period 1975-76. The coefficient of determinations (R^2s) between labour productivity with cropping-intensity, tractors, HYV area, infrastructure, draught animals, pumpsets, fertilizer, rainfall, holding size, man-land ratio, implements were found to be nonsignificant at 5% level. Therefore it is difficult to say about their association with labour productivity.

Table 2

Coefficient of Determination (R^2) between Agricultural Labour Productivity and Selected Variables in Karnataka : 1975-76

Sr. No.	Labour Productivity with		R^2
1.	Cropping intensity	x_1	(−).0006
2.	Ratio of area under cash crops to GCA	x_2	.3229*
3.	No. of tractors of P/100 hect. NSA	x_3	.0489
4.	Ratio of HYV area to food cropped area	x_4	(−).0232
5.	Composite index of infrastructure	x_5	.0446
6.	No. of draught animals P/100 hect. NSA	x_6	.0405
7.	No. of pumpsets P/100 hect. GCA	x_7	(−).0743
8.	Fertilizer Consumption P/hect. GCA	x_8	(−).0049
9.	Effective Literacy rate	x_9	.3578**
10.	Aunual rainfall (mm)	x_{10}	.1996
11.	Average size of holding (in hect.)	x_{11}	(−).0120
12.	Concentration ratio	x_{12}	.5126**
13.	Man-land ratio P/hect. NSA	x_{13}	(−).0119
14.	Ratio of NIA/NSA	x_{14}	.0052
15.	Agricultural Implements per 100/hect. NSA	x_{15}	.0294

** Significant at 1% level.

* Significant at 5% level.

Thus, on the whole, we can say that, individually, area under cash crops, literacy rate, concentration ratio in 1975-76 are the significant factors to explain the variations in labour productivity in Karnataka. And no decisive relation exists between labour productivity and other variables.

Now the moot question is, to what extent do all the variables together explain inter-district variations in labour productivity ? To answer this question, we have to resort to multiple regression analysis. However, before running the regressions to explain the variations in labour productivity, it is also necessary to check interrelationships between different explanatory variables. Such an exercise will help us to solve the problem of multicollinearity. The interrelationships between the explanatory variables are brought out by the correlation matrix given in Appendix Table-2 for the year 1975-76. The correlations are based on the observation relating to 19 districts of Karnataka.

Multiple Regression Models

After elimination of the interrelated variables, the multiple regression equations finally selected as the best are given below. They represent an effort to include as many of the variables specified as possible, because there is every reason to believe, on the theoretical grounds, that each of the variables specified has some effect on labour productivity.

$$Y_1 = \alpha + b_2 x_2 + b_4 x_4 + b_6 x_6 + b_7 x_7 + b_{12} x_{12} + e \quad ...(1)$$

$$Y_1 = \alpha + b_2 x_2 + b_4 x_4 + b_7 x_7 + b_9 x_9 + e \quad ..(2)$$

Where.

Y_1 = Labour productivity, x_2 = area under cash crops, x_4 = area under HYV, x_6 = draught animals; x_7 = pumpsets, x_9 =Literacy rate (Rural), x_{12} = concentration ratio, $\propto_5$ are constants, B's are the coefficients to be estimated, e = error term.

The above two equations have been fitted to the data for the year 1975-76. The equations are linear and have been estimated through the method of least squares.

Results of Multiple Regression

$$Y_1 = -5012.67 + 3737.28\, x_2^* - 577.859 x_4 + 1.9466 x_6$$
$$(2.35) \qquad (.470) \qquad (1.179)$$
$$-6.9730 x_7 + 9365.83 x_{12}^*$$
$$(.606) \qquad (2.047) \qquad R^2 = 6709^{**}, F = 5.30 \ldots (1)$$

$$Y_1 = -579.410 + 242.11 x_2 - 1846.65 x_4 - 11.2493$$
$$(1.491) \qquad (1.238) \qquad (.942)$$
$$x_7 + 5090.55 x_9^*$$
$$(2.781) \qquad R^2 = .5832^{**}\ F = .4.89 \ldots (2)$$

(Figures in brackets are 't' values of coefficients, ** indicate significant at 1 % level, indicate significant at 5 % level).

It is observed, from the above two regressions, that 58 % to 67 % of the agricultural labour productivity differential is explained by the selected factors in Karnataka during 1975-76. Only the area under cash crops (X_2), literacy rate (X_9) and the concentration ratio (X_{12}) appears to be significantly affecting the agricultural productivity in the state. The coefficients of cash-crops, literacy rate and concentration ratio have positive sign before them and are significant at 5 % level during the period under study. Individually also these are the only three factors which are significantly correlated with labour productivity. Other factors, namely, area under HYV, draught animals and pumpsets have no significant impact on labour productivity neither individually nor jointly.

Thus, we find that the area under cash crops, literacy rate and concentration ratio are the significant factors to explain the inter-district variations in labour productivity in Karnataka during 1975-76. However, it is observed that nearly 33 % of variation is still unexplained in the year under consideration.

Conclusions

The study reveals that there are wide disparities in agricultural labour productivity in Karnataka. From the cross-section study for the year 1975-76, it is found that the area under cash crops, literacy rate and unequal distribution of land holdings (CR) are the significant factors to explain the Interdistrict variations in agricultural labour productivity in Karnataka. Therefore changes in cropping pattern in favour of high valued crops and spread of education among rural population in the agriculturally backward districts may help correct regional imbalances in Karnataka.

Appendix Table 1

Sources of Variations in Agricultural Productivity in Karnataka : 1975-76

S. No.	District	Cropping intensity (GCA/NSA)	Area under cash crops (as % of GCA)	No. of tractors (per lakh hec. of NSA)	Area under HYV (as % of area under food crops)	Composite index of infrastructure	Draft animals (P/100 net NSA)	No. of pumpsets (per/100 hec. GIA)	Fertilizer consumption (N+P+K) (per hec. GCA) in kg.	Effective Literacy rate (Rural) (in %)	Rain fall (annual Avg. in mm.)	Average size of holding in hect.)	Concentration on ratio	Man/land ratio (per/100 hect. NSA	Net irrigated area (as % of NSA	Agricultural implements (plough + carts) per/100 hect. NSA)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1.	Kodagu	1.0384	60.48	206	9.92	114	168	7	12	48.25	3164.5	3.61	.6217	50	11.22	44
2.	Shimoga	1.1190	18.99	246	49.92	119	315	3	45	37.24	1687.5	2.22	.4903	111	42.41	68
3.	U. Kannada	1.1092	21.21	137	30.36	187	454	17	10	43.36	3630.8	1.31	.5832	164	20.45	95
4.	Chikmagalur	1.0840	43.79	223	17.20	93	235	18	13	36.85	2221.7	2.54	.5631	67	11.71	55
5.	D. Kannada	1.4284	30.79	400	39.72	117	442	37	31	45.49	5495.7	1.33	.5051	242	40.65	129
6.	Bellary	1.0644	32.61	93	41.10	93	85	7	36	23.14	915.9	3.37	.5384	62	15.16	20
7.	Hassan	1.1332	30.28	95	12.88	99	215	5	19	31.47	1166.8	1.99	.5208	85	17.13	70
8.	Tumkur'	1.0612	25.15	138	15.89	86	152	22	16	30.20	1043.4	2.15	.5366	88	15.77	50
9.	Chitradurga	1.1168	23.30	235	33.66	91	146	13	34	30.76	789.5	3.64	.5157	83	14.74	34
10.	Belgaum	1.0272	35.76	142	17.63	97	110	20	19	29.96	1064.0	3.03	.5497	77	14.80	27
11.	Mysore	1.2075	27.87	55	18.87	104	196	12	20	19.55	882.1	1.81	.4800	107	17.05	59
12.	Mandya	1.1969	21.21	112	13.04	114	190	7	63	22.71	853.4	1.23	.5194	121	32.55	87
13.	Dharwad	1.0289	46.57	234	26.17	117	90	14	11	39.88	901.7	3.94	.4809	57	6.96	21
14.	Bangalore	1.0362	19.09	270	13.47	130	234	35	40	28.74	1375.1	1.75	.5204	132	17.48	64
15.	Kolar	1.0974	33.38	209	24.60	102	209	33	24	23.76	972.5	1.81	.5080	133	20.98	67
16.	Raichur	1.0537	43.56	91	22.99	68	67	5	18	20.78	1245.3	6.64	.4866	46	12.19	15
17.	Gulbarga	1.0566	33.20	34	7.04	65	60	31	1	16.88	1101.8	5.43	.4817	40	2.46	12
18.	Bijapnr	1.0166	29.36	72	16.16	83	58	23	5	27.12	712.9	5.27	.4616	41	6.74	13
19.	Bidar	1.1913	27.36	34	21.36	92	99	39	5	20.94	1341.2	4.60	.4838	61	5.72	13
	Karnataka State	1.0771	32.80	135	21.27	100	130	16	18	29.48	1745.6	2.98	.5564	73	13.17	34

Source: Computed from : (i) Karnataka at a glance, 1975-76. Bureau of Economics and Statistics, Govt. of Karnataka, Bangalore (ii) Annual Season and Crop reports (corrected copy) Tables I, II, and III. Bureau of Economics and Statistics, Govt. of Karnataka, Bangalore, (iii) Estimates of Area, yield rate and production of principle crops in Karnataka: 1969-70 to 1975-76. Bureau of E and S, (iv) 12th Quinquenial Livestock census-1977. The Dept. of AH and V.S. Govt. of Karnataka, Bangalore, (y) Agricultural Census-1976-77, State Agricultural Census Commissioner, Govt. of Karnataka, Banglore-1978.

* Includes Roads, Villages electrified, No. of Commercial and co-operative banks, veterinary institutes, regulated markets and urbanization.

$$\text{**Concentration Ratio} = \frac{5000 - \frac{1}{2}\sum_{i=1}^{n}(q_i + q_{i-1})\, r_i}{5000}$$

where q_i = Cummulative % of area under size group i

r_i = % of holdings in size group i.

Appendix Table 2

Coefficient of Correlation Matrix 1975-76

Variables		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}
1. Cropping intensity (GCA/NSA)	X_1	1.0000														
2. Ratio of Area under cash crops to GCA	X_2	—.2931	1.0000													
3. No. of tractors p/100 hect. NSA	X_3	.3372	.0571	1.0000												
4. Ratio of HYV area to food cropped area	X_4	.3441	—.2786	.4364	1.0000											
5. Composite index of infrastructure	X_5	.1851	—.2650	.3717	.2763	1.0000										
6. No. of drafts animals p/100 hect. NSA	X_6	.5866†	—.3348	.5861†	.4138	.7678†	1.0000									
7. No. of Pump sets p/100 G/A	X_7	.2567	—.1853	.0828	—.1556	—.0176	.0346	1.0000								
8. Fertilizer consumption p/hect. GCA	X_8	.3044	—.4593*	.3604	.3682	.2070	.2766	—.2994	1.0000							
9. Effective literacy rate (Rural)	X_9	.1382	.3042	.7023†	.2771	.5944†	.6166†	—.1560	—.0314	1.0000						
10. Annual rainfall (mm)	X_{10}	.5844†	.1509	.5876†	.2823	.5062†	.7685†	.1959	—.0487	.7232†	1.0000					
11. Average size of holding (in hect.)	X_{11}	—.4447	.4284	—.4434	—.1783	—.6472†	—.7455†	.0371	—.5163	—.3580	—.3334	1.0000				
12. Concentration ratio	X_{12}	—.1598	.3414	.2063	—.1318	.4383	.3307	—.2414	.0043	.5667*	.4178	—.3640	1.0000			
13. Man/land ratio per/ hect. NSA	X_{13}	.7395†	—.4944	.6192†	.4021	.6122†	.8737†	.2660	.4291†	.3791	.6662†	—.7523†	.0937	1.0000		
14. Ratio of NIA/NSA	X_{14}	.6222†	—.4359	.5595†	.5797†	.4235	.7250†	—.1648	.7875†	.3313	.4477	.6658†	.0325	.7720†	1.0000	
15. Agricultural implements p/100 hect. NSA	X_{15}	.6855†	—.3471	.5750†	.2531	.6362†	.9147†	.0074	.4660*	4832*	.6650†	—.8448†	.2703	.9166†	.8047†	1.0000

† Significant at 1% level
* Significant at 5% level

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efficieney on hill farms in relation to modern techniques of production has been rather scanty, therefore, the present paper is an attempt in this direction. The main objectives of the study are to :

(i) evaluate the economic rationale of resource use on different farm size groups.

(ii) suggest the shift of resources from one category of farms to another category within the region.

DEMOCRACY'S
MILLION

Methodology

Present study is based on the information collected from the purposively selected eight villages namely Gharyana, Kiriya, Randole, Rayog, Shakrodi, Shakra, Suni and Thalli located along the embankment of river Sutlej. All the cultivators of the selected villages were stratified into two groups on the basis of operational holding i. e. Category—'A' less than 1.5 ha and category—'B' 1.5 or more than 1.5 ha. The total sample consists of 30 households in category 'A', and 30 households in category 'B', according to probability proportion to number of farms in each size.

The Cobb-Douglas production function was used to examine the production efficiency of individual inputs on two category of farms. The specification of the function is as below :

$$Y = a x_1^{b_1} x_2^{b_2} x_3^{b_3} x_4^{b_4} x_5^{b_5} x_6^{b_6}$$

Where Y = Gross returns (Rupees)

X_1 = Gross cropped area standardized in hectares

X_2 = Human labour days (days)

X_3 = Bullock labour days (days)

X_4 = Expenditure on manure and fertilizers (Rupees)

X_5 = Expenditure on seeds (Rupees)

X_6 = Expenditure on fixed factor (Rupees)

a = Intercept

b_1———————b_6-regression coefficients for X_1 through X_6

1. Gross returns (Y)

On account of aggregation problem it was very difficult to put the dependent variable in physical terms in the production function. Quantification of total farm output was thus done in money terms by converting the physical products into money values by multiplying yields of different crops with their respective harvest prices of the reference period.

2. Gross cropped area (X_1)G

The land as an important input was measured as hectares of land being operated per farm. Leased in and leased out area was taken special care of, while calculating total operational area. To avoid the problem of variation in the fertility and productivity of different fields from area to area and from farm to farm, adjustment in the land was made. Irrigation was considered as an important factor of variation in the productivity of land. 1.67[1] hectares of unirrigated land was considered equal to one hectare of irrigated land for normal year.

3. Human labour days used (X_2)

The human labour input was recorded in terms of work hours of man, women and children employed for different farm operations during the agricultural year. In this study human labour was measured in adult man-days of eight hours. It included family labour, permanent and hired labour. The variation in the efficiency of labour was removed by converting the female and child labour days into adult man days. The criterion used for conversion was that three female labour days (over 16 years) and four child labour days (12-16 years) be equal to two adult man days.[2]

4. Bullock labour days used

Bullock labour was defined in terms of eight hours day worked by a pair of bullocks. To avoid the multi-collinearity between human labour days worked with bullocks were not included as variable.

5. Expenditure on manure or fertilizers (X_4)

The physical quantities of different manures and fertilizers used on the farm were multiplied with their respective prices, to get the total expenditure. The total expenditure on these items was considered as explanatory variable in the analysis.

1. Rajkrishna, "Some production functions for the Punjab" *Indian journal of Agricultural Economics*, Vol. xix, Nos. 3 and 4, July-December, 1964, pp. 79-89.
2. K.C. Dhawan and P.K. Bansal, "Rationality of the use of various factors of production of different size of farms in the Punjab. *Indian Journal of Agrieultural Economics*, Vol. XXX 11 No. 3, July-September 1977, pp. 121-130.

6. Expenditure on seeds (X_5) :

This variable is defined as sum of the value of seeds for different crops calculated by multiplying the physical quantities of seeds with the respective prices.

7. Expenditure on fixed capital (X_6) :

This variable constitutes annual depreciation on farm implements and machinery, farm buildings, livestock and interest in terms of money value. A zero order correlation matrix for all explanatory variables was obtained for each category. It was found that no correlation coefficient was greater than 0.8. Thus, there was no problem of multi-collinearity. Secondly multi-collinearity is not necessarily a problem unless it is high relative to the over-all degree of multiple correlation among all variables simultaneously.

To evaluate the allocative efficiency of the resource use on the sample farms the following model was used :

$$\text{Allocative efficiency } X_1 = \frac{MVP_{xi}}{P_{xi}}$$

$$\text{Where } MVI_{xi} = bi - \frac{\bar{Y}\,(G.M.)}{\bar{X}\,(G.M.)}$$

Where G. M. represents geometric means Pxi = Factor cost of Xth imputs.

Results and discussion

A cursory glance on Table 1 reveals that maize and paddy was the main crop in Kharif and wheat in Rabi in both sets of farms. More than 10 per cent of the area was not put under cultivation by category 'B' farms in both crop seasons. The cropping intensity of category 'A' farms was higher than category 'B' farms.

The estimated production function equation for both sets of farms has been summarised in Table 2. It may be seen that the coefficient of gross cropped area, human labour and seeds were non-significant on category 'A' farms whereas expenditure on seeds and fixed resources were non-significant on category 'B' farms. On category 'A' farms the regression coefficients for bullock labour days, expenditure on fertillizer

Table 1

Cropping pattern (per farm)

Crops	Category 'A' farms	Category 'B' farms
Kharif season		
Maize (local) IR	0.074 (6.968)	0.304 (10.316)
Maize (local) UIR	0.246 (23.164)	1.411 (47.879)
Maize (HYV) UIR	—	0.096 (3.257)
Maize (HYV) UIR	0.278 (26.177)	0.288 (9.773)
Paddy (HYV) IR	0.356 (33.521)	0.524 (17.781)
Colocasia (local) IR	0.026 (2.448)	0.040 (1.357)
Fallow land	0.082 (7.722)	0.284 (9.637)
Total :	1.062	2.947
Ravi season :		
Wheat (local) IR	—	0 064 (2.172)
Wheat (local) UIR	0.024 (2.260)	0.248 (8.416)
Wheat (HYV) IR	0.416 (39.171)	1.008 (34.204)
Wheat (HYV) UIR	0.488 (45.952)	1.187 (40.278)
Barley (local) UIR	0.058 (5.461)	0.044 (1.493)
Other vegetables IR	0.048 (4.520)	0.102 (3.461)
Fallow land	0.028 (2.636)	0.294 (9.976)
Total :	1.062	2.947
Cropping intensity :	189.65	180.40

Note : Figures in parentheses are per cent area under each crop
IR = irrigated UIR = unirrigated.

Table 2

Coefficients of parameters, MVP's factors of production, ratios of MVP's to their factor costs on both sets of farms

Variables	Regression coefficient		MVP's of factors of production		Ratios of MVP's to their cost	
	Category 'A'	Category 'B'	Category 'A'	Category 'B'	Category 'A'	Category 'B'
(i) Intercept	61.480	45.210	—	—	—	—
(ii) Gross cropped area	0.145 (0.124)	0.311* (0.195)	284.493	538.895	0.568	1.076
(iii) Human labour days used	0.093 (0.83)	4.376† (0.153)	1.513	7.331	0.253	1.221
(iv) Bullock labour days used	0.097‡ (0.025)	0.084* (0.044)	11.794	11.394	0.655	0.633
(v) Expenditure on fertilizer and manures	0.296‡ (0.043)	0.246† (0.093)	1.953	1.413	1.953	1.413
(vi) Expenditure on seeds	0.069 (0.066)	(−)0.009 (0.165)	1.209	(−)0.158	1.209	(−)0.158
(vii) Expenditure on fixed assets	0.249‡ (0.050)	0.056 (0.077)	6.074	1.120	6.071	1.120
(viii) Coefficient of multiple determination	86%	84%	—	—	—	—

* Significant at 10% level of significance
† Significant at 5% level of significance
‡ Significant at 1% level of significance

and manures and fixed resources were 0.097, 0.096, 0. 249 respectively which were significant at one per cent level of significance, indicating that if expenditure on these three inputs were increased by one per cent, on an average there would be an increase of .097, 0.296, 0.249 per cent in the gross income respectively. Chances of increase in the income by means of increase in the seeds were poor in both the sets of farms. The regression coefficient of gross cropped area, human labour days, bullock labour days, fertilizers and manures were statistically significant on category 'B' farms.

The coefficients of multiple determination for category 'A' and category 'B' farms included in the production function indicated that 86 per cent and 84 per cent variation into total farm output has been explained by the explanatory variables.

The marginal values product of all the inputs were positive except expenditure on seeds on category 'B' farms, indicating that at the geometric mean level of input use, each input has positive addition to the gross returns.

The ratio of marginal value product to the acquisition cost of a factor i.e. marginal value product per rupee of input use was significantly higher than the unity for fertilizer and manure use on both the categories of the farms. This indicates that the farmers of both the sets can increase their yields by using more quantity of fertilizers and manures. The ratio of marginal value product to factor cost was significantly higher than unity for fixed resources on both sets of farms, indicating that there is stil scope of investment on the farm implements and machinery. On category 'A' farms ratios of MVP of gross cropped area, human labour days and bullock labour days to their acquisition costs were less than one, indicating thereby that there was excessive use of these factors. Therefore, the use of these factors should be reduced to minimize the losses. In case of category 'B' farms the ratio of MVP of bullock labour days and seeds to their cost was less than unity i.e. 0.633, 0.158 respectively. While in all other cases on 'B' group farms this ratio was more than one.

The regression coefficients of different factor inputs determined in the Cobb-Douglas type of function can also be used to estimate the returns to scale. The returns to scale may be increasing, constant of decreasing depending upon the sum of regression coefficients. In the present study the sum of regression coefficient were 0.949 and 1.032 on category 'A' and 'B' farms respectively (table 3). The sum of regression coefficients were tested for their deviation from unity. The 't' test indicated constant returns to scale in both cases.

Table 3

Returns to scale

Farm category	Sum of regression coefficients	Returns to scale indicated by ('t' test)
'A'	0.949	Constant
'B'	1.032	Constant

The foregoing discussions of both sets of farm organizations brought out that intensity of cropping has inverse relationship with size of the farms. The higher cropping intensity on category 'A' farm was because of availability of sufficient family labour during the peak operational period which was lacking in case of category 'B' farms. Wheat occupied more than 85 per cent of total cropped area in the Rabi season and maize and paddy covered about 90 per cent of the total cropped area in the kharif season. This clearly indicated that farmers of study area were not going for much diversification in crop production. The functional analysis of both categories of farms suggests that category 'A' farmers should curtail the use of human labour whereas the farmers of category 'B' may increase the expenditure on it. The group 'A' farmers may increase their returns either hiring out human labour to 'B' group farmers or hiring in land from them. Introduction of custom service for preparation of land is not possible in the study area, therefore, maintenance of bullock, labour to carry out timely farm operation is a must in the study area, these cost reduction is not possible. Both the categories of farmers could increase their income through intensive use of chemical fertilizers and manures. Group 'B' farmers should curtail investment on seeds and 'A' category farmers may invest more in this item. The analysis show that 'A' category farms should invest more on better type of implements and machinery. The returns to scale on both the categories of farms was constant which is a general feature of agriculture.

Productivity
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Farm Mechanization and Productivity

A. S. PATIL

Segregation of impact of tractorization and other inputs on productivity of crops is important in the present context of controversy over the role of mechanization in increasing productivity of land. The attempt has been made to separate out the effect of tractorization, manures, fertilizers, other capital inputs and human labour use on yields of major crops with the help of decomposition analysis.

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Indian agriculture has witnessed a noticeable structural change particularly with the introduction of high yielding varieties coupled with intensive use of irrigation and fertilizers, adoption of this biological technology in several regions of India accompanied by farm mechanization. There has been upward shift of agricultural production function. But the role of machine technology along with biological technology in increasing productivity on farms remains debated.

The studies conducted by Motilal[1], Lal[2], Mishra[3], Singh *et. al*[4] and NCAER[5] indicated that per unit yields were higher on tractor farms than that of bullock farms. These higher yields were attributed to the use of tractor technology and attempt has not been made to separate out effect of tractorization and use of other inputs on productivity. In this paper an attempt has been made to isolate the effect of tractorization and other factors on productivity. More specifically the objective of this paper is, to decompose the total change in per hectare output of different crops with the introduction of 'improved' technology (tractor power) of cultivation over 'traditional' technology (bullock power) and due to differences in input levels.

Sample and Data

The data utilized in the study pertain to Ahmednagar district of Maharashtra. Three-stage stratified random sampling was used to select tehsils, villages and sample bullock and tractor operated holdings. All the tehsils of the district were ranked on the basis of number of tractors and power threshers. Three tehsils, viz, Shrirampur, Rahuri and Kopargaon having the highest ranking performance with respect to these criteria were selected. In the selected tehsils villages were classified into three groups on the basis of tractor and thresher population. Three villages from each group were selected randomly. All the farms of these selected villages were listed and classified as bullock farms and tractor farms. A sample of 90 tractor operated holdings was selected randomly. The number of tractor operated holdings selected from each village were kept proportional to the size of tractor population in that village. To provide a proper basis for comparison of sample results, an equal size of sample of bullock operated holding was also selected randomly from the same selected villages following the same procedure.

The sampled farmers were personally interviewed and the input output data were collected with the help of specially designed schedule. The information was recorded with respect to the agricultural year 1979-80 through survey method.

As mechanization proceeded in the district, it was found that more and more bullock farms were using tractor custom service. Also, some tractor operated farms maintained at least one pair of bullocks to carry on certain operations. Keeping in view this, the sample holdings were further classified as :

		No.
A Bullock operated holdings		
(i) Pure bullock operated farms (BOF)	:	44
(ii) Bullock plus tractor custom (BOF-THF)	:	45
B Tractor operated holdings		
(i) Pure tractor operated farms (TOF)	:	40
(ii) Tractor plus bullock operated farms (TOF-BOF)	:	50

Before analysing the impact of farm mechanization on productivity it is necessary to have an idea about some characteristics of the sample farms. These are discussed below. The comparison is attempted between three categories only, viz, bullock operated farms, tractor operated farms and bullock operated farms hiring tractors.

Major Characteristics of the Sample Farms

The information on operational area, cropped area and intensity of cropping of three categories of farms is given in Table 1.

Table 1

Average Farm Size, Cropped Area and Cropping Intensity

Farm category	Net cultivated area per farm (ha)	Gross cropped area per farm (ha)		Cropping Intensity (Percentage)	
		I	II	I	II
BOF	7.09	8.90	10.50	125.50	148.00
BOF-THF	6.97	8.68	10.45	124.60	150 00
TOF	9.74	12.48	15.66	128.20	160.40

There was hardly any difference in the average farm size of pure bullock farms and bullock farms hiring tractor services. However, the difference between the farm size of pure tractor farms and these two categories was significant. There was no significant difference in the proportion of irrigated area between three categories of farms. About 90 per cent and 92 per cent of the total cropped area was irrigated on bullock farms and tractor farms respectively. Also, there was very little difference in cropping intensity[1] (I) between three categories of farms. However, cropping intensity (II) was significantly higher on tractor farms than that of bullock farms and bullock farms hiring tractors.

The proportion of total cropped area under different crops (Table 2) indicates that the percentage of area under cereals was comparatively higher on bullock

1. Cropping intensity (I) and Cropping intensity (II) calculated considering sugarcane as one crop in a year and it equivalent to two crops in a year respectively as the duration of sugarcane crop varies from one year to one and half years in Maharashtra.

Table 2

Cropping Pattern of Sample Farms

Farm category	Percentage of area under						
	Cereals	Sugar-cane	Cotton	Ground-nut	Pulses	Vege-tables	Grass
BOF	58.94	17.96	8 85	3.75	3.67	1.99	4.84
BOF-THF	53.98	20.39	9.00	4.75	2.72	3.86	5.30
TOF	47.83	25.52	13.02	4.03	1.87	4.85	2.88

farms and bullock farms hiring tractors than pure tractor farm, while the percentage of area under commercial crops viz, sugarcane, cotton, groundnut, vegetables was higher on tractor farms. About 5 per cent of the total cropped area was under fodder crops on bullock farms and custom farms.

The per hectare net income given in Table 3 clearly indicates that net income on tractor farms was markedly higher (32.96 per cent) than that of bullock farms and also farms hiring tractor services.

Table 3

Per Hectare Net Income of Sample Farms

	BOF	BOF-THF	TOF
Net Income	4363.52	4853.84	5801.90
(Rs)	(100.00)	(111.24)	(132.96)

Average Productivity of Major Crops

The use of tractors enables farmers, *inter alia* to achieve higher levels of productivity per unit of land, as with their help preparatory tillage and ploughing operations can be carried out satisfactorily and in time. The comparison of average yields per hectare of differant crops on three categories of farms given in Table 4 support the above observation. A comparison of the yield rates of tractor owners with bullock users shows that the per hectare yields realized by tractor owners

Table 4

Per Hectare Yield of Important Crops on Sample Farms

(in quintals)

Crop	Farm Category		
	BOF	BOF-THF	TOF
Wheat (HYVs)	25.40	25.80	30.29
Jowar (Hybrid)	35.30	37.60	38.96
Jowar (Local)	15.61	16.32	16.73
Groundnut	20.71	20.82	22.67
Cotton	9.21	10.09	11.96
Sugarcane (*adsali*)	1413.20	1543.60	1597.70

were higher by 7 to 21 per cent, in respect of the major crops. The yields of different crops on tractor farms were also higher by 4 to 18 per cent than that of bullock farms hiring tractor services. However, three higher yields on pure tractor operated farms may be attributed to the combine effect of using tractor technology for cultivation (in terms of thorough land preparation and timely operations) along with comparatively higher use of other inputs. The per hectare use of manures and fertilizers, and other capital inputs for different crops was higher on tractor farms than bullock farms and custom hiring farms. The use of human labour however, was lower on tractor farms for all crops except cotton crop than two other categories.

The decomposition model is developed to estimate the differences in per hectare yields of crops attributed to different factors on tractor operated farms, bullock operated farms and bullock operated farms hiring tractors.

Decomposition Model

The convenient econometric model for decomposing total change in output is the production function. For any production function, the total change in output is brought about by shift in the parameters that define the function itself and by changes in the quantity of inputs. The decomposition analysis could be undertaken with Cobb-Douglas per hectare production function.

In Logarithmic form, Cobb-Douglas production function for i^{th} Crop of Bullock Operated Farms* (traditional technology) is —

$$\text{Log } Y_i^B = \text{Log } A^B + a^B \text{ Log } N_i^B + b^B \text{ Log } F_i^B + C^B \text{ Log } K_i^B + u^B \qquad (1)$$

where,

Y_i^B = per hectare output of i^{th} crop in quintals;

N_i^B = per hectare human labour input (man days):

F_i^B = per hectare expenditure on manures and Fertilisers (Rs.)

K_i^B = value of capital services used per hectare,[1]

A^B is a scale parameter and a^B, b^B and c^B denote output elasticities of respective inputs;

u^B is a random disturbance term independently distributed with zero mean and finite variance.

Per hectare production function for i^{th} crop on tractor operated farms (improved technology) is :

$$\text{Log } Y_i^T = \text{Log } A^T + a^T \text{ Log } N_i^T + b^T \text{ Log } F_i^T + C^T \text{ Log } K_i^T + U^T \qquad ...(2)$$

Definitions of variables and parameters in (2) are the same as in (1)

Taking difference between (2) and (1), and adding some terms and subtracting the same terms;

$$\text{Log } Y^T - \text{Log } Y^B = (\text{Log } A^T - \text{Log } A^B) + (a^T \text{ Log } N^T - a^B \text{ Log } N^B + a^T \text{ Log } N^B - a^T \text{ Log } N^B) + (b^T \text{ Log } F^T - b^B \text{ Log } F^B + b^T \text{ Log } F^B - b^T \text{ Log } F^B) + (C^T \text{ Log } K^T - C^B \text{ Log } K^B + C^T \text{ Log } K^B - C^T \text{ Log } K^B) + (u^T - u^B) \qquad ...(3)$$

Rearranging terms in (3) :

$$\text{Log } Y^T - \text{Log } Y^B = [\text{Log } A^T - \text{Log } A^B] + [(a^T - a^B) \text{ Log } N^B + (b^T - b^B) \text{ Log } F^B + (C^T - C^B) \text{ Log } K^B] + [a^T (\text{Log } N^T - \text{Log } N^B) + b^T (\text{Log } F^T - \text{Log } F^B) + C^T (\text{Log } k^T - \text{Log } k^B)] + (U^T - U^B) \qquad ...(4)$$

Equation (4) can also be re-written as :

$$\text{Log}\left[\frac{Y^T}{Y^B}\right] = \text{Log}\left[\frac{A^T}{A^B}\right] + \left[(a^T - a^B) \text{ Log } N^B + (b^T - b^B) \text{ Log } F^B + (C^T - C^B) \text{ Log } k^B\right] + \left[a^T \text{ Log}\left(\frac{N^T}{N^B}\right) + b^T \text{ Log}\left(\frac{F^T}{F^B}\right) + C^T \text{ Log}\left(\frac{k^T}{k^B}\right)\right] + \left[\left(U^T - U^B\right)\right] \qquad ...(5)$$

The decomposition equation (5) involves decomposing the natural logarithm of the ratio of per hectare output obtained using 'improved' technology to 'traditional' technology of cultivation. It is approximately a measure of percentage change in output with the introduction of 'improved' technology of cultivation.[1] The first bracketed expression, on the left

* In this paper, we define tractor operated farms as using 'improved' technology and bullock operated farms as using 'traditional' technology.

1. Capital variable includes operating expenses of physical capital, value of irrigation expenses, insecticides expenditure, value of seed, bullock labour charges/tractor charges.

1. $\text{Log}\left(\frac{Y^T}{Y^B}\right) = \text{Log}(1 + X) \approx X$ for $|X| < 1$

where, X is a percentage change in output, it is approximately a percentage change because the higher order terms in Taylor Expression are discarded.

hand side is a measure of percentage change in output due to shift in scale parameter (A) of the production function. The second bracketed expression, the sum of the arithmetic changes in output elasticities each weighted by the logarithm of the volume of that input used, is a measure of change in output due to shifts in slope parameters (output elasticities) of the production function. The third bracketed expression is the sum of the logarithms of the ratio, for each input, of 'improved' to 'traditional' technology, each weighted by the output elasticity of that input; this expression is a measure of change in output due to difference in the per hectare quantities of labour, fertilizer and capital inputs used given the output elasticities of these inputs under 'improved' production technology.

Empirical Results

With decomposition equation (5), using the values of production parameters (Annexure) and the input levels, the total change in per hectare output of 5 major crops, viz, wheat (HYVs), *jowar* (hybrid), groundnut, cotton and *adsali* sugarcane has been decomposed into constituent factors. The effect of tractor technology and other inputs on output change has been examined by comparing, (*i*) Tractor operated farms vs. Bullock operated farms and (ii) Tractor operated farms vs, Bullock operated +Tractor hiring farms. The results are presented in Table 5 (A, B).

The per hectare production of different crops on tractor operated farms was higher by about 10 to 21 per cent and 4 to 18 per cent than that of bullock operated farms and bullock operated farms hiring tractors respectively. The increase in total output on tractor operated farms due to use of tractor power for cultivation is estimated between 4 to 11 per cent in comparison with farms using bullock power and about 4 to 6 per cent in comparison with farms using bullock power and also hiring tractors for cultivation of some crops. This implies that about 4 to 11 per cent more output per hectare could be obtained on TOF with the same level of inputs (human labour, fertilizers and capital) used on BOF or BOF-THF. Due to higher use of manures and fertilizers for different crops 2 to 10 per cent and 2 to 9 per cent of more output per hectare of different crops were obtained on TOF as

Table 5

Decomposition Analysis of Total Change in Per Hectare Output

(A) Tractor Operated Farms—Vs—Bullock Operated Farms

Item	Wheat (HYVs)	*Jowar* (Hybrid)	Cotton	Ground-nut	Sugar-cane (*Adsali*)
Total change in output (per cent)	19.25	10.37	21.00	9.49	13.40
Sources of change					
Percentage attributable to :					
1. Tractor technology	6.02	3.57	10.80	5.73	10.95
2. Changes in inputs					
(a) Human labour	—1.64	—3.80	1.17	—1.99	—1.34
(b) Manures and fertilizers	10.25	2.07	7.24	4.07	2.79
(c) Capital	5.55	7.62	1.09	0.60	0.99
Total : due to all inputs	14.16	5.89	9.50	2.68	2.44
Total change in output (estimated) due to all sources	20.18	9.46	20.30	8.31	13.39

compare to BOF and BOF-THF, respectively. The more expenditure on capital inputs on TOF increased the per hectare output by 1 to 8 per cent and 2 to 3.5 per cent as compared to BOF and BOF-THF, respectively. The negative contribution of human labour to output of different crops (except cotton) is estimated as the per hectare employment of human labour on BOF and BOF-THF was higher than TOF. Thus, the use of three inputs together contributed to increase the output of different crops between 2 to 14 per cent on TOF.

Conclusions

The results obtained using the decomposition model for segregating change in output of different crops revealed that there is a close association between actua

(B) Tractor Operated Farms—Vs.—Bullock Operated Farms Hiring Tractors

Item	Wheat (HYVs)	*Jowar* (Hybrid)	Cotton	Ground-nut	Sugar-cane (*Adsali*)
Total change in output (Per cent)	17.80	4.00	10.50	8.90	3.60
Sources of change					
Percentage attributable to :					
1. Tractor technology	6.30	4.30	4.51	4.83	3.87
2. Changes in outputs					
(a) Human labour	−0.84	−3.34	0.79	−1.58	−1.46
(b) Manures and Fertilizers	8.66	1.88	5.13	2.72	0.17
(c) Capital	3.48	2.16	0.17	1.72	0.15
Total : due to all inputs	11.30	0.70	6.09	0.76	−0.71
Total change in output (estimated) due to all sources	17.60	5.00	10.60	8.45	3.16

and estimated output for all crops. It indicates that the decomposition equation used to measure the change in output showed very satisfactory results. Also, the tractorization along with more use of manures and fertilizers and other capital inputs has increased the productivity on tractor owning farms as compared to bullock farms and tractor hiring farms. Farm Power thus acts as a catalytic agent in the process of efficient utilization of irrigation, seeds, fertilizer etc. and assists in conducting the desired farm operations timely and effectively. This indirectly reflects on the productivity of land and crops.

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ANNEXURE

Per Hectare Production Function Estimates for Different Crops

Farm category	Constant in Log	Regression coefficients of N	F	K	R^2	No. of observations
		Wheat (HYVs)				
BOF	—2.865	0.125	0.389‡	0.460‡	0.484	44
BOF-THF	—2.551	0.297†	0.267‡	0.390‡	0.554	45
TOF	—1.266	0.166	0.314‡	0.275†	0.411	40
		***Jowar* (Hybrid)**				
BOF	—2.797	0.210	0.270‡	0.583‡	0.721	29
BOF-THF	—0.313	0.395‡	0.205†	0.143*	0.601	30
TOF	—3.444	0.498‡	0.186‡	0.563‡	0.675	29
		Groundnut				
BOF	—0.955	0.705†	0.065	0.049	0.607	21
BOF-THF	—3.863	0.591‡	0.312‡	0.327	0.766	28
TOF	—0.198	0.482†	0.018	0.057	0.395	24
		Cotton				
BOF	—3.689	0.806‡	0.141	0.050	0.421	21
BOF-THF	—2.882	0.625‡	0.156	0.068	0.320	28
TOF	—3.411	0.646‡	0.236	0.069	0.634	24
		Sugarcane (*adsali*)				
BOF	—2.645	0.475†	0.322‡	0.250	0.731	44
BOF-THF	—1.204	0.450†	0.226*	0.193†	0.460	46
TOF	—2.154	0.512†	0.200†	0.294†	0.451	40

Note : ‡ Significant at 1 per cent level.
† Significant at 5 per cent level.
* Significant at 10 per per level.
N: Human labour days.
F: Manures and fertilizers (Rs)
K: Capital inputs (Rs)

Productivity
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Factors Influencing Agricultural Productivity

R. L. SAGAR
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Agricultural productivity of an area or a region may be referred to as the outcome of factors like soil productivity, climatic conditions, levol of technology, utilisation resources etc. Some of the factors like farm size, tenancy, input availability, price of inputs and produce etc. also greatly influence productivity.

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Agricultural productivity of an area or a region may be referred to as the outcome of factors like soil produtivity, climatic conditions, level of technology, utilisation resources etc. Some of the factors like farm size, tenancy, input availability, price of inputs and produce etc. also greatly influence productivity.

For the purpose of the present study, productivity of crops has been conceptualised as a manifestation of farmers' behaviour in obtaining crop yield by utilising the resources at his disposal.

Methodology

Selection of Agro-Economic characteristics and their Measurement

Nine agro-economic characteristics (variables) relevant for the area were selected for study. These were measured as follows :

X_1 *Farm Size*—Actual area under cultivation in hectare.

X_2 *Average Size of Plot*—Total farm area in hectares was divided by the number of non-contiguous plots and was expressed by the formula :

$$\text{Average size of plot} = \frac{\text{Total area of the farm in hectare}}{\text{Number of non-contiguous plots}}$$

X_3 *Status of Land Ownership*—Percentage of area owned by the cultivating household.

X_4 *Irrigation Index*—Percentage of the total cultivated area under irrigation.

X_5 *Farm Mechanisation*—Level of use of labour saving (human and animal), time saving and efficient working devices for farm operations. Measured by 'farm mechanisation index' developed by Samanta (1977).

X_6 *Cropping Intensity*—Proportion of total annual cropped area to the size of holding, expressed in percentage.

X_7 *Index of High Yielding Varieties*—Percentage of area under high yielding varieties to the total area under cultivation.

X_8 *Level of Use of Organic Manure*—Organic manure used in tonnes per hectare of gross cropped area.

X_9 *Level of Fertiliser Use*—Measured by the formula of Standardised Index of Level of Fertiliser use developed by Singh (1981).

Productivity of Crops

Productivity in farming was measured by crop yield index formula developed by Yang (1980). For this purpose six principal crops of the area i. e. Jute, Paddy (*aus*, *aman* and *boro*), Wheat, Potato, Pulses (gram, lentil, *mung*, *urid* and pea) and Oilseeds (*tori*, *rai* and *til*) were taken into consideration.

Area of Study and Selection of Respondents

The study was conducted in Haringhata block of Nadia district, West Bengal. There are 9 Gram Panchayats in Haringhata block. From each gram Panchayat 2 villages were selected at random on the basis of probability proportion to the number of households in the villages.

The farmers in each of the 18 selected villages were stratified into three categories marginal (below 1 hectare) small (1-2 hectares) and medium (more than 2 hectares). A proportionate random sample was drawn from each category from each village and the size of sample was not less than 4 percent of the population. In this way, 100 marginal, 75 small and 50 medium (total 225) respondents were selected which formed the sample of the study.

The data were collected from January to March, 1981.

Findings and Discussion

Zero order correlations between the 9 selected agro-economic characteristics and productivity of crops were computed separately for the marginal, small, medium and pooled sample of farmers and are presented in Table 1.

Table 1

Relationship of Productivity of Crops of the Marginal, Small, Medium and Pooled Sample of Farmers with the Agro-Economic Variables

Agro-Economic variables	Zero-order correlation			
	Marginal farmers (N=100)	Small farmers (N=75)	Medium farmers (N=50)	Pooled sample of farmers (N=25)
X_1 Farm size	0.250*	−0.181	0.073	0.032
X_2 Average size of plot	0.302†	0.884†	0.270	0.577†
X_3 Status of land ownership	0.871†	0.837†	0.900†	0.510†
X_4 Irrigation index	0.501†	0.387†	0.301*	0.390†
X_5 Farm mechanisation	0.167	0.891†	0.958†	0.423†
X_6 Cropping intensity	0.942†	0.876†	0.385†	0.703†
X_7 Index of high yielding varieties	0.194	0.923†	0.333*	0.396†
X_8 Level of use of organic manure	0.340†	0.981†	0.935†	0.371†
X_9 Level of fertiliser use	0.341†	0.329†	0.789†	0.384†

* Significant at 1 per cent level
† Significant at 5 per cent level.

From the data presented in table 1 the following inferences may be drawn.

Farm Size—Productivity in farming was neutral to farm size, except in case of the marginal farmers, where it was positively and significantly correlated.

Average Size of Plot—Productivity in farming was positively and significantly correlated with average size of plot of the marginal, small and pooled sample of farmers.

In case of medium farmers no significant relationship between productivity in farming and average size of plot was observed, which indicated that productivity in farming of the medium farmers was neutral to average size of plot.

Status of Land Ownership—Productivity in farming was positively and significantly correlated with the status of land ownership of the marginal, small, medium and pooled sample of farmers, which indicated that ownership of farm land was an important variable in determining the farmers' productivity in farming.

Irrigation Index—Productivity in farming was positively and significantly correlated with the percentage of farm land under irrigation of the marginal, small, medium and pooled sample of farmers, which indicated that irrigation was an important variable in determining the farmers' productivity in farming.

Farm Mechanisation—Productivity in farming of the marginal farmers was not significantly related with their level of farm mechanisation. This may be due to the fact that the marginal farmers had low level of use of farm machinery.

Productivity in farming was positively and significantly correlated with the level of use of farm machinery of the small, medium and pooled sample of farmers.

Cropping Intensity—Productivity in farming was positively and significantly correlated with the cropping intensity of the marginal, small, medium and pooled sample of farmers, which indicated that multiple cropping was an important variable in determining the farmers' productivity in farming.

Index of High yielding Varieties—No significant relationship between productivity in farming and the index of high yielding varieties was observed in case of marginal farmers, probably because of their low level of adoption of high yielding varieties of crops.

Productivity in farming was positively and significantly correlated with the level of use of high yielding varieties of the small, medium and pooled sample of farmers.

Level of Use of Organic Manure—Productivity in farming was positively and significantly correlated with the level of use of organic manure of the marginal, small, medium and pooled sample of farmers which indicated that use of organic manure was an important variable in determining the farmers' productivity in farming.

Level of Fertiliser Use—Productivity in farming was positively and significantly correlated with the standardised index of level of fertiliser use of the marginal, small, medium and pooled sample of farmers, which indicated that the fertiliser use was an important variable in determining the farmers' productivity in farming.

Conclusion

The study indicated that status of land ownership, irrigation index, cropping intensity and level of use of organic manure and fertiliser were significantly related with productivity in farming of all the three categories of farmers and were important in agricultural extension work.

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Productivity
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Tractorization and Productivity

S. GIRIAPPA

The objective of the paper is to evaluate the performance of tractor farms compared to bullock farms, in the case of paddy and commercial crops as to productivity, suitability and other situational factors. Bullock farms seems to perform slightly better in paddy and sugarcane but other commercial crops show a higher productivity under conditions of tractorization. Where capital is available (larger holdings, commercial crops), the better performances of tractors cannot be underrated.

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Though the appropriateness of tractorization has been questioned under Indian farming conditions, it has been increasing in intensity and impact in specified regions and crops. Its contribution is expected to increase to over 15 percent of total farm power by 2000 AD from the current level of 4 percent.[1] When it was introduced, the ultimate objectives were to increase crop intensity, yield and productivity besides labour saving and timeliness. But many studies have found that these objectives were rarely achieved and that tractors were opted in regions where labour was a critical input and timely operations demanded quick power. Though the rate of profitability is not higher when compared to the bullock farms, tractorization has been adopted for status reasons also.[2]

This paper attempts to compare bullock and tractor farms in a tractor intensive area and evaluate the latter's performance in terms of profitability and other factors. Also, it tries to compare paddy with commercial crops like sugarcane and analyse the impact of tractorization on them. That is, how far commercial crops lead to higher level of tractorization as against paddy under the specific situations, would be a crucial issue in deciding the technology on the crop-mix.

1. *Report of the National Commission on Agriculture, 1976* Part X, Chapter on Farm Power.
2. See for an excellent review on the topic, H.P. Binswanger, *The Economics of Tractors in South Asia : An Analytic View* Agricultural Development Council, New York and International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, 1978.

Crop mix and intensity in sample farms

The analysis of the paper is largely based upon the study done in Erode taluk of Tamil Nadu during 1976-77.[3] The tractor intensity was quite high (between 200 to 275 ha/tractor) in the sample areas and Table 1 gives the nature of crop-mix, intensity and other particulars in the case of bullock and tractor farms. It is seen that the average size per holding is more than double in tractor farms. Cropping intensity is higher in the case of latter (1.77) as against 1.69 in bullock farms). The gross cropping intensity (equalizing longer duration commercial crops area with paddy) shows little differences between the two types of farms (it is higher in tractor farms only by 2.8 percent).

Table 1

Crop-mix and Intensity in Sample Farms (in ha)

Particulars	Bullock farms	Tractor farms
No. of sample units	25.00	25.00
Net cropped area	75.06	191.89
Average size per holding	3.00	7.68
Gross cropped area	126.40	339.50
Cropping Intensity	1.69	1.77
Gross C.I.	2.19	2.25
Share of paddy (%)	50.50	53 10
Share of commercial crops (%)	30.30	27.00
Share of paddy (in Gross C.I. terms)	38.70	41.90
Share of commercial crops (in gross C.I. terms)	46.50	42.60
Farm workers/holding	2 90	4 50
Bullocks/holding	1.80	1.10
Farm workers/ha	0.82	0.50
Bullock pairs/ha	0.35	0.08

Source: S. Giriappa and K.V. Govindaraju, *Power Use on Farms in India*, ISEC, Bangalore, pp. 23-24.

3. S. Giriappa and K.V. Govindaraju, *Power Use on Farms in India* ADRT Unit, Institute for Social and Economic change, Bangalore, 1978 (Mimeo).

In the gross cropped area, paddy has a larger share in both the farms 50.5 and 53.1 percent while the commercial crops (sugarcane, turmeric and banana put together) share 30.3 and 27.0 percent respectively. It is seen that increase in paddy area share in tractor farms is compensated by decrease in commercial crop area by more or less an equal amount. In gross crop-intensity terms, the share of paddy and commercial crops is 38.7 and 46.5 percents in bullock and 41.9 and 42.6 percents in tractor farms respectively. The average number of farm workers is higher in tractor farms (4.5 as against 2.9 in bullock farms). But in per hectare basis, bullock farms register a higher number of workers (0.82) than the tractor farms (0.50); this is true for bullocks also (0.35 as against 0.08). It it seen that due to tractorization, about 0.32 men and 0.27 bullocks are displaced per hectare.

Performance of paddy and commercial crops

Table 2 describes power and material input-income ratios, yield, income-cost ratio and average power use in bullock and tractor farms with respect to paddy and commercial crops. For paddy, the yield rate is higher in tractor farms by about 8.0 percent, but the latter use 7.5 percent more material capital. This phenomenon is quite evident in commercial crops also. So, it may be construed that yield increase is more due to increased use of material inputs (especially chemicals) than to tractorization as such. Though the yield rate is higher, the tractor farms perform slightly poor in terms of income-cost ratio (rate of profitability). The inefficiency is traced back to a slightly higher rate of power-income ratio, indicating that in terms of power use, the tractor farms require higher efficiency. The horse-power requirement is 2.8 times higher than in bullock farms, which is not witnessed in the commercial crops.

Sugarcane has a lower income-cost ratio in both the farms, but it is again the bullock farms that fare better than the tractor farms. When compared to paddy, power is utilized more efficiently but it is material capital input that performs inefficiently, more so in the tractor farms. Turmeric is the only crop that performs well both in terms of power and materials use. And it is here that the tractor farms register a higher income-

Table 2

Performance of paddy in commercial crops. (Rs/ha)

Particulars	Paddy	Sugarcane	Turmeric	Banana*	Commercial crops	All crops
Bullock farms						
Power cost	1073.5	2650.0	3100.0	3500.0	2944.5	1604.0
Material cost	1283.5	4875.0	6570.0	5787.5	5700.5	2560.2
Yield	48.4	1375.0	45.0	2125	—	—
Income-cost ratio	2.35	2.08	2.96	2.50	2.50	2.40
Unit cost	53.60	6.02	234.0	4.81	—	—
Power-income ratio	.17	.15	.11	.13	.13	.16
Materials-income ratio	.21	.28	.21	.23	.24	.22
Total horsepower	234.2	624.0	746.0	860.0	718.6	370.0
Tractor Farms						
Power cost	1202.3	2903.0	3212.5	3606.3	3121.5	1660.4
Material cost	1375.0	5376.5	7501.0	6250.6	6246.4	2621.0
Yield	52.50	1500.0	52.5	2250	—	—
Income-cost ratio	2.33	2.06	3.11	2.49	2.49	2.37
Unit cost	54.00	6.07	224.0	4.82	—	—
Power income ratio	.18	.15	.09	.13	.13	.17
Materials-income ratio	.21	.30	.20	.23	.25	.22
Total Horse power	660.2	1555.0	1660.0	1936.0	1651.8	886.5

* In bunches Horse power equivalent for a man hour is 0.1, for bullock pair hour 1.0 and for tractor hour 32-0.

Source : S. Giriappa and K.V. Govindaraju, *op. cit.*, pp. 64-65.

cost ratio (3-11 as against 2.96) than the bullock farms, being more efficient both in power and materials use. Banana, though registering a higher efficiency in power use has a lower material use efficiency in the farms when compared to paddy. The rate of profitability seems to be more or less same, though the yield rate is higher in the tractor farms.

On the whole, it is seen that commercial crops fare better than paddy in terms of power use, but not so as regards material capital. The proportion of material cost is quite high in them and they register a higher rate of profitability than paddy. The performance of bullock farms is slightly better than the tractor farms as in paddy. The power use ratio is 2.3 times higher in tractor farms for commercial crops, meaning a better power performance.

For the entire crop-mix any way, the bullock farms have a slight edge over the tractor farms and it is the power ratio that is responsible for the latter's lower level of performance (as was the case with paddy). Keeping the bullock farms as base, the rate of profitability declines by 1.2 percent for all crops, 0.4 percent for commercial crops and by 0.9 percent for paddy in the tractor farms. But between paddy and commercial crops, the difference in profitability seems to be not much in the tractor farms (6.9 percent as against 6.3 percent in bullock farms).

If we assume that the share of commercial crops in tractor farms is same as in the bullock farms (30.3 percent of gross cropped area), then the difference in rate of profitability narrows down and the former registers an equal performance. The income-cost ratio would be 2.39 for all the crops in the tractor as against 2.40 in the bullock farms.

Conclusions

No doubt, the bullock farms perform slightly better than the tractor farms especially in paddy and sugarcane. But crops like turmeric are more amenable to tractorization and so, if tractorization is encouraged, it should be more in such cases where it could supplement efficient power use with increased productivity. That is, for some crops, only tractorization might seem more appropriate than bullock farming. Appropriate technology can be capital-intensive, but it can, in the process be efficient also. Since the effective power ratio in paddy in the tractor farms (with bullock farms as base) is relatively higher than the commercial crops, substitution of a certain quantum of tractor power by human and bullock power should seem more productive. But by improved power ratio, the commercial crops register an effective tractorization capacity of about 20 per cent higher than in paddy.

But the main advantage of tractorization should not be underrated. It is seen that the average size of holding in the bullock is less than half that in the tractor farms. And it may be too unwieldy to employ large human and bullock power owing to scale and time factors. For large holdings, tractorization could maintain the level of performance as in the small holdings which might not be the case under bullock farming. Actually, in the study, it was found that custom farms, hiring tractor services did fare better than the bullock farms in efficient power use.[4]

The analysis shows that the level of performance in the tractor farms could be stabilized or improved only with higher capital input and is indicative of the general developmental process. Even if it were to be more human and bullock labour, the tempo of the process could not be maintained without addition of capital to the said labour. Human and bullock labour could perform efficiently upto a certain size of holding, beyond which capitalized technical change (whether appropriate or imported) seems to be the right thing to choose. From this angle, tractorization could be recommended for such farms and crops toward improving the stability.

4. Ibid, p. 65.

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Technology for Rice Farming

DR. K. D. SHARMA

Improved rice farming technology has also been worked out by different hill states, keeping in view the local practices and situations. Because of the socio-economic constraints of the hill farmers, greater emphasis needs to be laid on the low input or zero input technology. This paper discusses the availability and transfer of technology for increasing production and productivity of rice in the hilly regions of India.

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Out of 40 million ha under rice in India, approximately 2 million ha area lies in the Hills Zone, spread over Jammu and Kashmir, Himachal Pradesh, Hills of Uttar Pradesh and West Bengal, and North Eastern Hill states of Assam, Manipur, Meghalaya, Nagaland, Tripura, Arunachal Pradesh and Mizoram. According to the 1980-81 statistics, the average yields of rice in most of hill states were either below or at par with the national average of 1338 kg/ha, except for Jammu & Kashmir with an average yield of 2065 kg/ha. In addition to other factors, natural calamities like drought, hailstorm *etc.* were responsible for low average yields in these states. In Kashmir valley, rice is cultivated from 1500 to 2250 m altitude and almost 100 percent of this 200,000 ha area is irrigated and transplanted, although some area between 1800 and 2250 m is direct seeded. Moreover, this is a mono-cropped area and hence higher yields are obtained. In Himachal Pradesh, rice is cultivated from plains/foot hills upto an altitude of 2000 m in 100,000 ha area, only 60 percent of which is irrigated and about 50 percent is direct seeded. In the eight hill districts of Uttar Pradesh, only 10 to 15 per cent of 150,000 ha is irrigated and dryland rice cultivation is extensively practised there and also in the north eastern hills. In addition, "jhoom" or shifting cultivation is also practised in some of the north eastern hill areas. Thus there is a great diversity of agro-climatic conditions under which rice is cultivated in hilly areas—from foot hills to high hills, from very high rainfall to very low rainfall areas, under transplanted and direct-seeded conditions and from warm tropical to temperate areas. Undulating topography complicates the situation still further and the agro-climatic conditions change greatly within short distances of 15-20 kms, especially in Himachal Pradesh, where 1100 m is the critical altitude for varietal adaptation and very few varieties can cross this critical altitude in either direction. Therefore, wide adaptability with stable performance under varied agro-climatic conditions is desired/necessary for hill rice varieties.

Major Problem

In order of their importance, the major problem of rice cultivation in hills are cold tolerance, rice blast disease and drought resistance. Some pockets suffer from hail storms and need shattering-resistant varieties, others have wild rice problem and need purple-leaved varieties to eradicate wild rice and still others have preference for red rice and other quality characteristics. Rice hispa, stem borer and leaf folders among the insect pests, and glume blotch, *Helminthosporium* and sheath rot among other diseases of rice are the major plant protection problems of the area. Due to these problems, high-yielding varieties of rice, suitable for cultivation in different agro-climatic zones, were not available till recently. But the situation has now changed, because with the introduction of high-yielding varieties and rising levels of nitrogen application and high plant density, the disease and insect pest problems are becoming more acute. However, cold, blast and drought are the three major factors which result in low yields in hilly areas. Three main research stations, Khudwani in Kashmir, Palampur in Himachal Pradesh and Almora in Uttar Pradesh, are engaged in tackling these constraints of rice cultivation in northern hills, while the ICAR Research Complex for NEH Region, Shillong, is catering to the needs of north eastern hills. The main emphasis at Khudwani is on cold tolerance, at Palampur on cold tolerance and blast resistance and at Almora on drought resistance. A good deal of work at these three locations has resulted in the release of a number of high-yielding varieties for specific situations, some of which are also doing well in some areas of north eastern hills. It is a well known fact that in modern times the contribution of seed towards a good crop is about 50 percent, the remaining being contributed by the relevant technology. This being so, the varietal improvement aspect of the crop comes first, which, of course, itself is the result of a multi-disciplinary approach.

Progress of variety improvement in the hills

Ever since the intensification of research on rice under the All India Coordinated Rice Improvement Project (AICRIP) at Khudwani and Palampur from 1970 onwards and at Almora a few years ago, a good number of improved high yielding, cold tolerant, blast resistant varieties for specific situations in Jammu and Kashmir, Himachal Pradesh and Uttar Pradesh hills have been released.

(a) *Jammu and Kashmir*. In J & K, K 84 and K 116 with high cold tolerance were releasd to replace the old widely adapted variety China 1039, which was introduced in the state in 1958. Barkat, tested under the designation of K 78-13, with a yield of 4 t/ha, as compared to 2 t/ha for the local, was released for altitudes ranging from 1675 to 2130 m. K 332, which was 10 days earlier in maturity than Barkat and has a yield of 4.1 t/ha, has been released for altitudes ranging from 1675 to 2285 m. K 333, which is 20 days earlier and has a yield of 3.81 t/ha, can be grown at still higher altitudes in Kashmir. K-39-96-1-1-1-2 has been found suitable for altitudes ranging from 1500 to 1675 m. in Kashmir valley and has an average yield of 6.7 t/ha, as compared to 4.56 t/ha for China 1039.

(b) *Uttar Pradesh Hills*. In Uttar Pradesh hills, VL8, a medium duration variety for low altitude irrigated areas and another variety, VLK 39, with short duration and suitable for medium altitude irrigated areas, have been released. VL 16 and HPU 776, with yields of 4.1 and 3.7 t/ha, respectively, have also been found to be suitable for Uttar Pradesh hills under irrigated conditions. Under upland conditions, VL 206 (2.3 t/ha) and VR 7 (2.1 t/ha) have been found suitable for spring planting, and VRS 245-2-2, VRS 242-1-2 and VRS 212-1-3-2-1, which are medium tall short duration varieties, have been found suitable for the June planting in U.P. hills.

(c) *Himachal Pradesh*. In Himachal Pradesh, the release of IR 579 in 1975 triggered the cultivation of semi-dwarf *indica* varieties with improved plant type and good grain quality. This variety had a yield potential of more than 6 t/ha and an average yield of 4 t/ha, but its cultivation was restricted from foot hills upto an altitude of 1050 m only, because it suffers from asynchronous flowering and late maturity in areas above this altitude due to cool temperatures. This variety however, has gone a long way in improving the lot of the farmers in low hill areas. In 1978, Himdhan, a medium coarse-grained tall *indica* variety with a yield potential of 6 t/ha and an average yield of 3.5 t/ha, was released for low and mid-hills upto an altitude of 1500 m to replace the old widely adapted variety China 988. It had given a very stable performance under varied agro-climatic conditions in the state and out-yielded China 988 by a margin of 14 per cent. It was suitable for direct seeded as well as transplanted conditions, moderately resistant to blast but susceptible to glume blotch. With the release of another two semi-dwarf *indicas*, Himalaya-1 and Himalaya-2, in 1982, the high yielding-cum-high quality rices can now be successfully cultivated upto an altitude of 1650 m above m.s.l.

The experimental line HPU 734, a very early maturing selection from the cross IR 8/Tadukan, which was named Himalaya 1, was recommeded for low, mid and high hills upto 1650 m altitude, and HPU 71, an early maturing selection from the cross Improved Sabarmati/Ratna, which was named Himalaya 2, for low and mid hills upto about 1300 m altitude. Himalaya is a high yielding, cold tolerant, blast resistant and early maturing fine-grained quality variety with an average yield of 3.9 t/ha, showing an increase of 25.8, 14.7 and 2.6 per cent over checks IR 579, China 988 and Himdhan, respectively. Himalaya 2, is a high yielding, blast resistant and early maturing fine-grained scented variety with an average yield of 3.5 t/ha, showing an increase of 20.7, 2.9 and 2.8 per cent over checks IR 579, China 988 and Himdhan, respectively (Table 1).

In minikits on farmers' fields during 1980, Himalaya 1 and Himalaya 2 averaged 3.6 t/ha each and out-yielded the local checks by a margin of 44 per cent. The yields as high as 7.7 t/ha for Himalaya 1 and 6.3 t/ha for Himalaya 2, were recorded on a progressive farmer's field.

HPU 741, a cold-tolerant selection for earliness and uniform maturity with the designation of IR 3941-45-Plp 2B from the cross CR 126-42-5/IR 2061-213, has been found to be very suitable for rainfed and irrigated tracts of Himachal Pradesh upto an altitute of 1650 m.

In transplanted experiments conducted throughout

Table 1

Grain yield (t/ha) of Himalaya 1 and Himalaya 2 in Himachal Pradesh hills, India*

Year	Himalaya 1	IR 579 (check)	China 988 (check)	Himdhan (check)	Himalaya 2	IR 579 (check)	China 988 (check)	Himdhan (check)
1976	—	—	—	—	3.9(4)	3.3(4)	—	3.5(4)
1977	4.7(6)	3.8(6)	4.0(6)	4.8(6)	3.1(3)	2.8(3)	3.3(3)	3.3(3)
1978	3.9(11)	3.5(11)	3.6(11)	4.2(11)	3.6(11)	3.5(11)	3.6(11)	4.2(11)
1979	4.0(10)	2.2(10)	3.4(10)	3.5(10)	3.3(10)	2.2(10)	3.4(10)	3.5(10)
1980	3.3(15)	2.8(4)	2.6(6)	2.7(11)	3.7(4)	2.8(4)	—	—
MEAN	3.9(42)	3.1(31)	3.4(33)	3.2(38)	3.5(32)	2.9(32)	3.4(24)	3.6(28)
Increase over respective checks (%)	—	25.8	14.7	2.6	—	20.7	2.9	−2.8

* Values in parentheses indicate the number of locations for which yields were averaged.

Himachal Pradesh, under varied agroclimatic conditions from 1977 to 1983, HPU 741 averaged 3.7 t/ha, showing an increase of 20.1, 6.4 and 11.6 per cent over checks, IR 579, China 988 and Himdhan, respectively. In rainfed upland experiments conducted from 1980 to 1983, it averaged 2.8 t/ha showing an increase of 27.3 and 16.4 percent over checks China 988 and Himdhan, respectively (Table 2). A perusal of the data on rainfall pattern clearly indicated that during all the four years of testing under rainfed upland conditions, crop experienced severe to moderate drought stress from flowering to maturity. Inspite of such an aberrant rainfall trend at the critical growth stage, the performance of HPU 741 was highly promising in comparison to checks including the widely adapted land rice China 988.

Table 2

Grain yield (t/ha) of HPU in Himachal Pradesh, India

Year	HPU 741	IR 579 (check)	China 988 (check)	Himdhan (check)
(A) *Transplanted Experiments*				
1977	3.9(5)	—	3.5(5)	3.6(5)
1978	3.7(7)	3.5(7)	3.6(7)	4.0(7)
1979	3.8(6)	2.5(6)	3.3(6)	3.3(6)
1980	3.7(16)	3.0(8)	3.0(11)	3.0(16)
1981	3.8(14)	3.5(7)	3.9(9)	3.7(14)
1982	3.4(9)	2.6(5)	3.8(5)	3.3(9)
1983	3.6(15)	—	3.5(15)	2.8(12)
Mean	3.7(72)	3.1(33)	3.5(58)	3.3(69)
Increase over respective checks (%)	—	20.1	6.4	11.6
(B) *Rainfed Upland Experiments*				
1980	2.3(3)		2.1(3)	2.4(3)
1981	3.4(4)		2.8(4)	3.8(4)
1982	2.6(8)		1.9(8)	1.7(8)
1983	2.9(5)		2.3(5)	2.4(5)
Mean	2.8(20)		2.2(20)	2.4(20)
Increase over respective checks (%)	—		27.3	16.4

Figures in parentheses indicate the number of locations for which yields were averaged.

In comparison to VLK 39, in transplanted experiments from 1978 to 1981, HPU 741 and VLK 39 were almost at par with yields of 3.75 and 3.70 t/ha, respectively. But in upland rainfed experiments at four locations in 1981, HPU 741 outyielded VLK 39 by a significant margin of 34.5 per cent. However, during 1983, when the drought was more acute, it again out-yielded VLK 39 by a margin of 16.2 per cent. In minikit trials on farmers' fields during 1980, 1982 and 1983, it averaged 2.9 t/ha over 63 locations and outyielded other local checks by 45.6 per cent. The yields as high as 6.9 t/ha were recorded by this variety on a progressive farmers field. HPU 741 has already been released in Cameroon (West Africa).

Still another variety, IET 5878 [*viz.* HPU 8020 Bala late 6 mutant], is being tested in H. P. under minikit trials. Based on its consistently good performance in H. P. from 1976 to 1980 in 30 different environments, its average yield was 4.8 t/ha, outyielding the checks IR 579 by 15.4 per cent, China 988 by 20.0 per cent and Himdhan by 10.1 per cent. The yield potential, however, is 8 t/ha. In minikit trials on farmers' fields, it gave 87.2 to 104.3 per cent higher yield than locals. Its early maturity, resistance to blast and *Helminthosporium*, very high yields (both under direct sown and transplanted conditions-especially in low altitude areas) make it suitable for low hill and plain areas of the state. In AICRIP trials for the plains also, it has done very well and occupied first, second or one of the top five positions in India. It was released in Pondicherry in 1982.

In Himachal Pradesh, yield stability is an important aspect as rice is cultivated under varied agroclimatic conditions in the state. Yield stability parameters for 20 rice strains, tested during 1977 and 1978 in nine environments at different elevations in Himachal Pradesh, indicated that Himalaya 1 and HPU 741 had high yields and high stability, whereas Himalaya 2 had average yield and high stability.

Excellent performance of these varieties on farmers' fields and yields above 6 t/ha obtained on the farmers' field are fair indications that if introduced in a big way on the farmers' fields, alongwith improved agricultural technologies, these varieties can play a significant role in increasing productivity.

Perhaps due to the prevalence of different races of blast in Kashmir, H. P. and U. P. hills, the varieties developed and found suitable for Kashmir are in general, highly susceptible to blast in H. P. and the ones developed and found suitable for H. P. are highly susceptible to this disease in U. P., as is obvious from the reaction of major rice varieties (including the most recent ones) to blast in Kashmir, H. P. and U.P. hills. However, it can be seen that suitable high-yielding varieties are available for specific situations in different agro-climatic zones of the hills and need only to be popularised in the concerned areas by the extension and development agencies.

Performance of Indian Hill Rices in Other Countries

Based on the rigorous screening of our elite breeding materials against cold and blast by multilocation testing in different agro-climatic conditions, we have been contributing our best performing lines to the International Cold Tolerance Nureries (IRCTN) every year. Some of these lines/varieties from Kashmir and H. P. have proved to be very good sources of cold tolerance, alongwith a good degree of resistance to blast in the international tests conducted through International Rice Research Institute (IRRI) and are being utilized in the rice improvement programmes of different countries. Some of the selections from H. P. have done very well in countries like Nepal, Brazil, Madagascar, Cameroon, Korea, Philippines etc. As a result of this international cooperation and testing through IRRI, Nepal has recently released in 1982 two of our cold tolerant plast resistant selections, IR 3941-4-P1p2B and IR 2298-Plp B-3-2-1-1B, under the names of Kanchan and Himali, respectively, for temperate regions of Nepal upto 1500 m. Kanchan is a fine-grained (LS) variety of 143 days with an average yield of 7.6 t/ha, as compared to 4.3 t/ha for China 45 (LS) and 4. 58 t/ha for Laxmi (LS), used as checks. Himali is a scented fine-grained variety with an average yield of 7.18 t/ha and 145 days duration. Another selection, HPU 741, which is still being tested under minikit trials in H. P. has already been released in Cameroon (West Africa).

Rice Farming Technology

Improved rice farming technology has also been worked out by different hill states, keeping in view the local practices and situations. Because of the socio-economic constraints of the hill farmers, greater emphasis needs to be laid on the low input or zero input technology. In addition to the use of improved seed, seed treatment with fungicides, raising of community nurseries in water scarcity areas, time of sowing and transplanting, age of seedlings, proper water management, timely and proper application of adequate doses of fertilizers depending upon the type of rice cultivation—transplanted or upland rainfed, correction for zinc deficiencies, if detected, interculture and weed management, and use of plant protection measures for the control of pests and diseases, on which adequate information is available for each area, needs to be propagated vigorously by the extension agencies. Some of the recent findings of the soil scientists and the agronomists of H. P. Agricultural University are of interest in this regard :

1. In transplanted paddy, ponding of water and use of ammonical fertilizers have been found to be very useful in increasing paddy yields. Use of urea supergranules has also been found to be very effective in increasing yields.
2. Irrigated paddy in the acid soils of Palampur area does not respond to the application of phosphorus, but a linear response to nitrogen application up to 120 Kg N/ha has been obtained. Application of potash was found ineffective.
3. By basing the fertilizer requirements on the equations developed under the soil test-crop response correlation studies, it is possible to achieve a yield target up to 40 Q/ha of paddy. This approach is more scientific and economical.

4. Delay in transplanting paddy in Palampur area beyond July 5 resulted in significant yield reduction.

5. Highest grain yield was obtained by transplanting 50 day old seedlings of Himalaya-1, but the optimum age of seedlings for Himalaya-2 was observed to be 40 days.

6. DCD (Dicyndiamide) treated urea, supplying 80 Kg N/ha, when applied in two equal splits (at transplantlng and 40 days after transplanting), gave similar grain production in rice as obtained with ordinrry prilled urea supplying 120 Kg N/ha, saving 40 Kg N/ha. Similarly, applying 58-87 Kg N/ha through urea supergranules or sulphur-coated urea gave comparable results, obtained with ordinary urea supplying 87-116 Kg N/ha. Here also the modified forms of urea saved 29 Kg N/ha.

7. The use of organic wastes in rice revealed that tea waste (left over after brewing tea) at one tonne/ha and *Eupatorium* (a common weed) @ 2 t/ha significantly increased rice grain yield over untreated control.

8. Closer spacing (15×10 cm) gave higher grain yield under stress conditions (moisture, soil and late planting). whereas 15×14 cm was optimum for most of the recommended varieties under normal conditions. However, Himalaya-2 needed closer planting (15×10 cm) for optimum grain output.

9. In transplanted rice, application of machete granules @ 1.5 Kg a. i./ha and Molinate + 2, 4-D @ 1.5 Kg a. i./ha were found highly effective in controlling weed adequately. In upland rice, the application of machete (1.5 Kg a. i./ha) or saturn (1.5 Kg a. i. /ha) or Goal (O. 15 Kg a. i./ha), followed by one hand weeding, was effective.

Strategy for increased rice Production in hills

In this context, the example of Korea, with similar problems of cold and blast, is worth emulating, because in 1970 Korea developed Tongil—a high yielding *indica-jopanica* cold tolerant rice variety, the rapid spread of which, together with the advanced rice farming technology and year round intensive farmers' training, made Korea completely self-sufficient in rice production in 1975. The development of another 14 varieties up to 1978, which were better than Tongil in terms of yield, quality and resistance to pest and diseases, alongwith improved cultural parctices, enabled Korea to set a record of 4.94 t milled rice/ha the highest national average rice yield in the world in 1978. The availability of adequate number of high-yielding, cold tolerant, blast resistant varieties for specific situation in the major rice growing areas of hills, some of which are also high quality rices, give stable proformance under varied agro-climatic conditions in hills and are suitable for cultivation in other hilly areas of India, can go a long way in increasing productivity of rice in hilly area if these are rapidly spread in areas of their adaptability along with the available improved rice farming technology. Some of the varieties, capable of ensuring stability of performance and to a certain extent delinking production from the vagaries of monsoon, are also availabe and need to be released and propagated quickly in Himachal Pradesh. Extension, therefore, appears to be the weakest link between the available technology and the potentiality of increased rice production. In addition, socio-economic factors also appear to be responsible for low rice production in the hill states, because of the poor financial status of the farmers in the hills. If these bottlenecks are removed, hills zone is capable of becoming not only self-sufficient but surplus in rice production.

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Field Efficiency of Power Operated Farm Machinery

N. L. MAURYA
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Different parameters affecting field efficiency were analysed and field tested. The results revealed that the field efficiency increases with increase in the length-width ratio and size of plots for different tillage operations. The rate of increase in the efficiency was higher in the beginning and reduced considerably beyond the length-width ratio of 3:1. *It was also observed that method of operation affects the field efficiency. For general ploughing operation land method with varying idle run and for other tillage operations land method with constant idle run were found to be most efficient. The predicted field efficiency with the help of theoretical equations developed were found to be in good agreement with the observed field efficiency.*

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Farm machinery management is one of the important aspects of farm management. It deals with optimization of machinery aspects of agricultural production involving efficient selection, operation, repair, maintenance and replacement of machinery. The efficient management of farm machinery helps to reduce the cost per unit of crop produced and thus improves the cost-benefit ratio.

The basic requirement of a machine is to perform its intended function satisfactorily. A machine is said to have performed satisfactorily if it had done a good quality work of sufficient magnitude at minimum cost. This is possible only when machine works efficiently. The field efficiency of a machine is defined as the ratio of effective field capacity to theoretical field capacity, expressed in percentage. The effective field capacity of a machine is the actual rate of coverage based on total field time. Theoretical field capacity is the rate of coverage when the machine is performing its function 100% of the time at rated forward speed and covering 100 % of its rated width. The effective field capacity of any machine is affected by machine parameters, field parameters and several other parameters and it is always less than theoretical field capacity. As a result, field efficiency for any given machine is always below 100 % sometimes going as low as 50 %. However, the efficiency can be improved by adopting efficient management practices, which are described in the following sections.

Factors Affecting Field Efficiency

As mentioned above, field efficiency is a function of machine parameters, field parameters and several other parameters. Machine parameters are selection of power unit and machinery, their condition and flow of material to and away from the machine. Field parameters include size, shape, topography and surface condition of the field. Factors such as method and speed of operation, terrace layout, row end turning space, and skill of operator, which may be influenced by any or both of the above parameters and also managerial decisions, are listed under other parameters. Each of the above parameters are discussed below.

1. *Selection of power Unit* : Selecting the proper power level is a most difficult problem, because the cost of power is a significant item in many farm operations and hence some logical procedure must be followed. The principal factors to be considered in choosing the most suitable type of power for a given farm set-up are size of the farm, topography of land, crops and kind of farm, soil characteristics and size of fields. With the introduction of small tractors, it is possible to use tractors profitably on as small as 5-10 hectare size farms. To take full advantage of soil for production of different crops, the optimum range of power needed is 0.50—0.75 hp per hectare. This range can be considered for selecting the size of the power unit, if no precise details are available. The tractor parameters, which affect the field efficiency are traction device and turning radius, in addition to general condition of the tractor. From tractive performance point of view, the crawler tractors perform best at low speeds (below 6.5 kmph), while wheel tractors perform best at higher speeds (Domier *et al*, 1971). In wheel tractors, efficiency of 4-wheel drive tractor is much higher than 2-wheel drive tractor. Tractors having less turning radius will give higher field efficiency, but the turning radius of tractor alone does not matter, as it is influenced by the implement attached to the tractor. It is advisable for such of the users, who own only one tractor, to go for a general purpose tractor.

2. *Selection of Machinery* : Once the power unit has been selected, the machinery should be selected to suit the power unit. If the machine size is too small, the operating cost will be excessive and untimely operations may lower both the quality and quantity of the work. If the size is too big, the operation becomes difficult to perform due to shortage of power. The following table gives the approximate power requirement for different machines, which may help a user to select a machine suitable to his power unit (ASAE Year Book, 1962; Bainer *et al*, 1963, Lennemark, 1967; Hunt, 1977; William and Hammond, 1978).

Table 1

Draft, Speed and Power required for Different Operations

Sl. No.	Machine	Draft, kg/metre width	Speed kmph	Drawbar power required hp/ metre width
1.	Plough	650-1600	5-8	19.0-30.0
2.	Single acting disc harrow	60-195	5-9	2.0-4.0
3.	Tandem disc harrow	120-240	5-9	4.0-5.0
4.	Spike tooth harrow	45-90	5-9	1.5-2.0
5.	Spring tyne harrow	110-220	5-9	4.0-4.5
6.	Roller	45-90	5-8	1.5-2.0
7.	Seed drill	45-120	4-6	1.0-2.0
8.	Planter	120-180	4-6	2.5-3.0
9.	Rotary hoe	45-90	6-10	1.5-2.0
10.	Cultivator	45-135	3-8	1.5-2.0
11.	Mower	90-150	5-8	2.5-3.0
12.	Combine	—	3-5	10.0-15.0

The drawbar power required for different machines was computed on the basis of lower draft and higher speed combination and vice versa. The drawbar horse power for a 2-wheel drive tractor will be around 50-60 % of brake horse power (Hunt, 1977).

The efficiency of a machine depends not only on the suitable match with its power unit, but also on the rated width actually utilized. With implements such as harrows, cultivators, mowers and combines, it will be practically impossible to utilize the full width of the machine without occasional skips. The tillage experiments conducted at Agricultural Engineering Institute, Raichur (Maurya *et al*, 1975), showed that the machine width actually utilized was only 90 % of its rated width.

In addition to the size of machine, the factors such as trade mark, trade name, model, ease of operation, ease of adjustment, adaptability to different working conditions, quick change of units, manoeuverability, repair and maintenance facility, safety and comfort should be taken into account, while selecting a field machine. These criteria should also be considered for selection of power unit.

3. *Condition of machine.* As minor repairs and adjustments are attended in the field, the time spent on these aspects is considered as time loss which affects the field efficiency. Limited studies conducted at AEI, Raichur by the authors have shown that the time loss due to such interruptions for tillage machines may be in the order of 2-3%. In a planting study (Renoll, 1969), the time required for adjustment was found to be about 6%, while using a planter with fertilizer attachment. Renoll (1972) reported the time loss for adjusting the machine to be in the range of 3-7% for ploughing, planting, cultivating and spraying. The loss for harrowing was reported as 1-3% of the total time. To reduce such losses, the machines are to be maintained properly and the essential tools must be carried with the outfit, while going for field operations.

4. *Flow of Material to and away from the machine.* The effective field capacity and field efficiency of machines like seed drills, planters, fertilizer spreaders, dusters, etc., are affected by the promptness with which the containers are refilled as soon as they become empty. Similarly, the field efficiency of different harvesting machines is a function of how quickly the harvested material is unloaded from the containers. In case of trailed combines, 4-17% of field time may be lost in moving away the grain from the machine dependig upon the system of removing the grain (Bainer *et al*, 1963). If the system employed is changing of wagons, time losses will be lower. But, if the grains are to be unloaded from the tank of the combine, then the time loss will be more. In case of grain drills, the time loss due to filling up of the tank may be around 10%. Renoll (1969) reported that 21% of the total time was lost in adding the fertilizer and seed while using a planting machine on a 4-hectare field. He also reported that 3-5%, 10-14% and 7-9% of the total time was lost in adding seed, fertilizer and spray chemicals respectively in a planting operation. Not only the machine system but also the management decisions play an important role here. He reported (1970) an increase of about 15% in effective field capacity when the method of handling water for chemical spray was improved, on a 4-row planter. Though these time losses are inevitable, they can be minimized by selecting the suitable type and size of machine and skilful handling of the problem by the operator.

5. *Size and Shape of Field.* Different studies have shown that the size and shape of the field have considerable effect on field efficiency. Total number of turns per unit area with a given width of implement is inversely proportional to the length of the plot (Bainer *et al* 1963). In ploughing studies Mitchell and Beer (1965) showed that the percentage of total time spent in turning was an exponential function of average row length. Renoll (1969) reported that long narrow fields with long rows were usually more efficient in machine use than short narrow fields. It was found that there was a trend of increase in field efficiency with increase in length-width ratio and size of plot (Maurya *et al*, 1975, 1977 and Maurya, 1977). It was also observed that the rate of increase in field efficiency was more in the beginning and decreased with increase in length-width ratio and size of plot. After a length-width ratio of 3:1, the rate of increase in field efficiency reduced considerably (Maurya *et al*, 1975; 1977). Under Indian conditions, one hectare plot with a length-width ratio of 3:1 may be quite appropriate to adopt. (Maurya, 1977).

6. *Topography and Surface Conditions of the Field.* Topography and surface conditions of the field affect the field efficiency. Mitchell and Beer (1965) reported that more work was accomplished on flat lands compared to slopy lands. During tillage experiment at Agricultural Engineering Institute, Raichur, it was found that effective field capacity reduced in case of slopy plots as a result of reduction in speed, while

going against the slope. Undulated and rough field surface also causes reduction in the speed resulting in lower effective field capacity and efficiency. If the surface is too much undulated and rough, particularly in head lands, it results in considerably high turning time. Renoll (1969) reported that average turning time per turn for different operations on rough surface increased in the order of 18-28%, when compared to smooth turning surface.

7. *Method of Operation*. Method of operation affects the idle travel and turning losses which, in turn, influence the field efficiency. Field studies have shown that these losses varied from 8 to 16% of total field time depending upon method of operation (Maurya and Devadattam, 1978; 1979). Four common tillage methods were analysed theoretically and equations were developed to determine the field efficiency (Maurya, 1977); Maurya and Devadattam, 1978; 1979). For ready reference, these methods are described in brief and the final equations for each method are given herewith.

(i) *Land Method*. In this method, entire plot is divided into several plots termed as lands. A land can be worked either by constant idle run or varying idle run.

(a) *Constant Idle Run*. In this method, first a land of suitable width say, w_c is marked and then the land is worked maintaining a constant idle travel. Thus, when this land is completed, another land of equal width also gets completed, as shown in Fig. 1 (a). Thereafter, the next land is marked and worked similarly. This process is continued until the whole plot is over. Towards the end of the operation, if it is difficult to get two lands, each having width w_c, little wider or narrower lands may be taken depending upon the situation.

This method can be very well adopted for most of the field operations except ploughing, where the soil is to be thrown in a particular direction. However, this method is quite suitable with reversible ploughs. The field efficiency can be predicted by the following formula.

$$\eta = \frac{KL}{L+2l_o+w_c+1.14r+(3\pi r-w_i)\frac{h}{w}} \qquad ......(1)$$

Where,

η = Field efficiency

K = Fraction of machine width actually utilized

L = Length of plot

l_o = Length of outfit (tractor with implement)

w_c = Land width for constant idle run method

r = Turning radius of outfit

w_i = Width of implement

h = Head land width

W = Width of plot

(b) *Varying Idle Run*. In this method, the first land is marked at 3/4 of the land width and subsequent lands are marked at full land width, say w_l. Working in the first land starts with casting and continues till ¼ of the land is left at the centre. This central portion is completed by gathering around the second ridge. Thus, by the time first land is completed ¼ of the second land also gets completed, leaving only 3/4 of land width as in the first case. This method is shown in Fig. 1 (b). The process is continued until the whole plot is completed except the last two lands, wherein casting is done in both the lands until they are reduced to ¼ of the land width. Then both the lands are finished by gathering. This method is very common for ploughing operation. The field efficiency for this method can be predicted by the following formula.

$$\eta = \frac{KL}{L+\frac{w_1}{2}+1.14r+(3\pi r-w_i)\frac{h}{w}} \qquad ...(2)$$

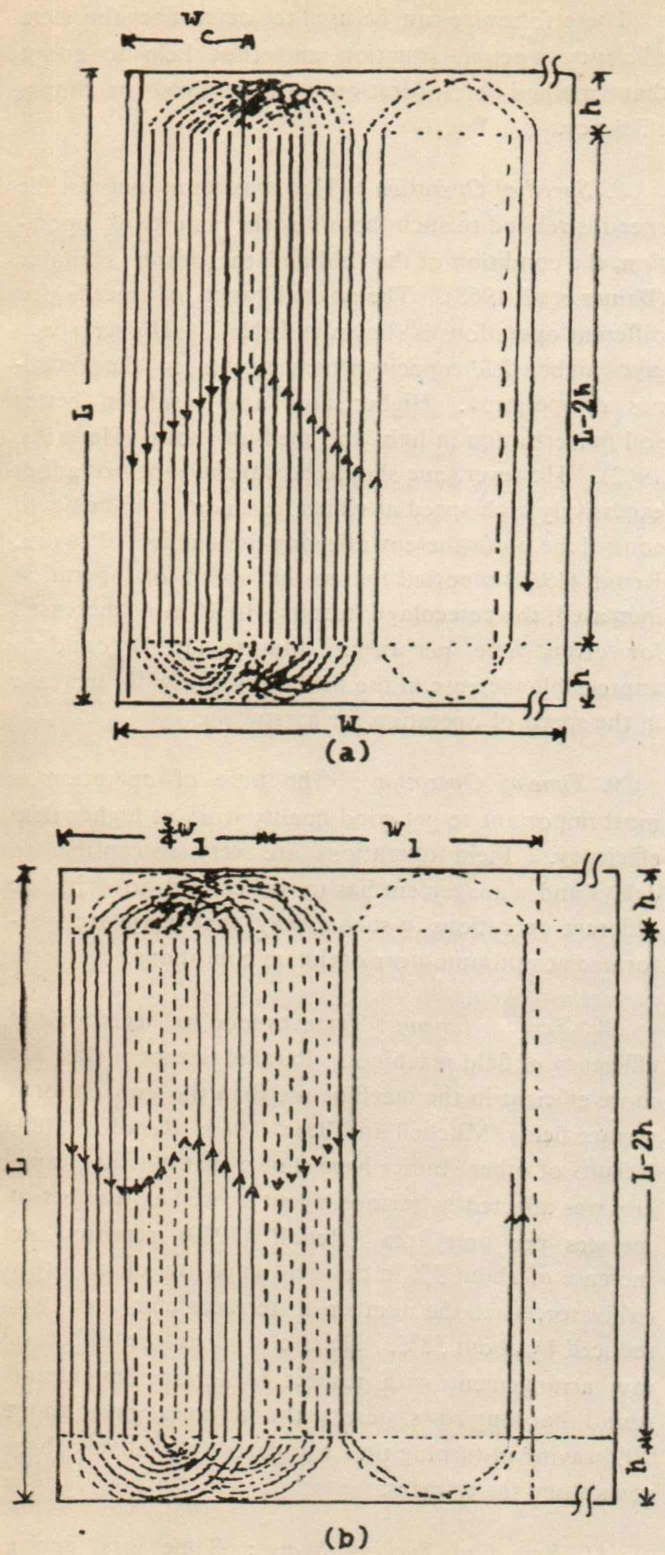
Where, w_1 = Land width for varying idle run method.

Round and Round Method: In this method, a plot can be worked either from centre to side or side to centre.

(*a*) *Centre to Side*: In this method, a replica of the field is marked at the centre, which is worked by opening a ridge in the centre and gathering around it. After this piece of land is over, the remaining portion is finished by taking four loop turns at each corner, as shown in Fig. 1(c). This method is also used specifically for ploughing.

The following formula gives the field efficiency.

$$\eta = \frac{KL}{L+4\pi r-\left(2.5\pi r+\frac{w_i}{2}\right)\frac{h}{w}} \qquad ...(3)$$



(a) Constant Idle run

(b) Varying Idle Run

Fig. 1 Different Methods of Field Operation

(*b*) *Side to Centre* : It is not common with tillage operations as the worked soil is trampled by the outfit in this method, while taking the loop turns. Side to centre method with cross lands or without cross lands is sometimes adopted for ploughing (Hine, 1959). The first method is limited in its use to only square plots and the other can be used only with mounted ploughs. However, this method is quite common with harvesting equipment. Due to limited use, this method has not been studied.

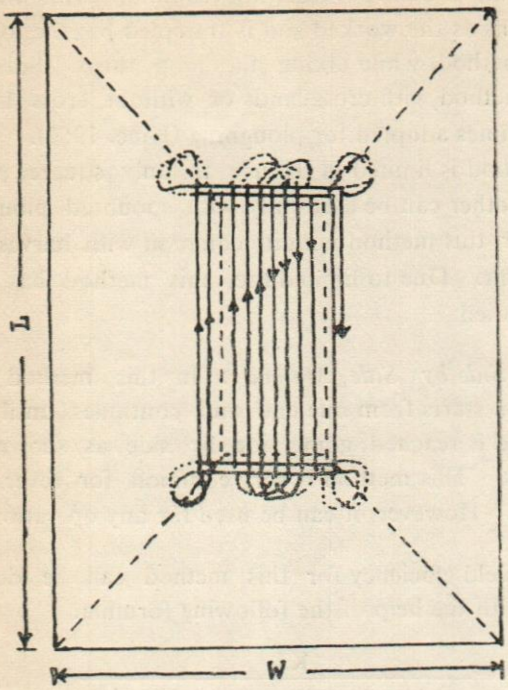
(*iii*) *Side by Side Method* : In this method the operation starts from one end and continues until the other end is reached, going side by side as shown in Fig. 1(d). This method is very common for reversible ploughs. However, it can be used for any operation.

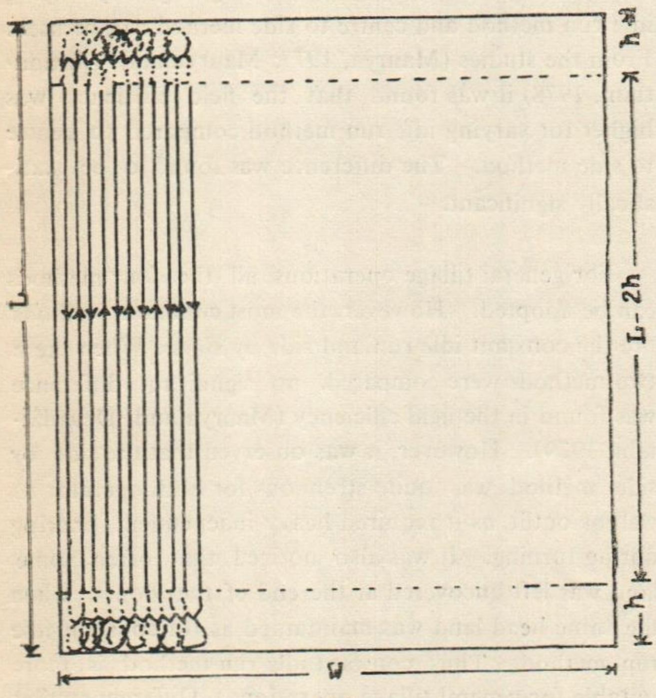
The field efficiency for this method can be determined with the help of the following formula.

$$\eta = \frac{KL}{L - w_i + 6.28r + (3\pi r - w_i)\frac{h}{w}} \quad \ldots (4)$$

As stated earlier, for general ploughing, only varying idle run method and centre to side method can be used. From the studies (Maurya, 1977; Maurya and Devadattam, 1978) it was found that the field efficiency was higher for varying idle run method compared to centre to side method. The difference was found to be statistically significant.

For general tillage operations, all the four methods can be adopted. However, the most common methods are the constant idle run and side by side. When these two methods were compared, no significant difference was found in the field efficiency (Maurya and Devadattam, 1979). However, it was observed that the side by side method was quite strenuous for both operator as well as outfit, as it required heavy independent braking during turning. It was also noticed that often some land was left uncovered at the end of the bouts, when the same head land was maintained as for constant idle run method. Thus, constant idle run method is more suitable for general tillage operations. Different studies Maurya *et al*, 1975; Maurya, 1977; Maurya and Devadattam, 1978; 1979) have shown that the field efficiency could be accurately predicted with the help of theoretical equations developed.





(c) Centre to Side

(d) Side by Side

Fig. 1 Different Methods of Field Operation

These formulae can be used to determine the field efficiency in actual situation and thus help to adopt that method of operation, which gives maximum efficiency.

8. Speed of Operation : The maximum permissible speed is related to such factors as the nature of operation, the condition of the field and the power available (Bainer *et al*, 1963). The normal range of speeds for different operations is shown in Table-1. Higher speed gives higher field capacity which results in the timeliness of operation. Higher speed also results in better soil pulverization in light and medium soils (Hawkins, 1962). However, one should be careful not to adopt excessively high speed at which he finds it difficult to control the outfit thereby affecting the quality of work. Renoll (1969) reported that as the speed of operation increased, the percentage turning time also increased for given time per turn. Maurya (1977) found no appreciable increase in the field efficiency with increase in the speed of operation for harrowing.

9. Time of Operation : The time of operation is most important to get good quality work at higher field efficiency. Field operations are very susceptible to delays and management has to be careful to schedule different operations in such a way that they are performed at optimum/near optimum conditions.

10. Terrace Layout : Terraces tend to decrease the efficiency of field machines. Parallel terrace fields are more efficient in the machine use than the conventional terrace fields (Mitchell and Beer, 1965; Renoll, 1969). Results of other studies have shown that machine capacity was affected by terrace layout as well as number of terraces per unit area. Renoll (1970) reported an increase of about 9% in the field capacity of a 4-row cultivator, when the number of terraces/unit area was reduced by about 55%. He also studied the effect of raw arrangement with respect to terrace layout and found that long rows across the terraces gave about 20% saving in turning time compared to relatively short rows along the terraces.

11. Row End Turning Space : Time loss during turning the outfit is of considerable importance. It amounts to 5-10% of total field time (Renoll, 1969; 1970). Similar observations were also made during tillage experiments conducted at Agricultural Engineering Institute, Raichur. Minimum turning time is achieved when the turning area is smooth and wide enough to allow an easy semi-circle turn. According to Renoll (1969), minimum turning space for mounted implements should be $2\frac{1}{2}$ times the length of the tractor for tri-cycle tractor and $3\frac{1}{2}$ times for four wheel tractor. Hine (1959) reported that for mounted ploughs 6 to 7 metre and for trailed ploughs 7-8 metre wide head lands were required depending upon the number of bottoms.

12. Skill of the Operator : The operator plays a significant role in influencing the field efficiency of any machine in addition to the quality of work. Though, no quantitative data are available, the influence of the operator on field efficiency can be easily seen. A skilled and careful operator will be able to keep power unit and machine in perfect condition, make the required adjustment quickly, plan his strategy in such a way as to reduce the time required for flow of materials and to away from the machine, select the most suitable speed, method of operation and optimum area. It is absolutely essential to have a suitable operator as without that, inspite of every perfection, the machine will poorly perform.

In addition to all these, one of the most important parameters is the management. It is entirely for the management to select a suitable power unit and the matching equipment, keeping in view the factors influencing the selection of these items. Management has to ensure proper maintenance, repair and replacement to keep the machine and power unit in good condition. The flow of material to and away from the machine may require an improved method, which may involve managerial decision and may be beyond the scope of the operator. Size and shape of the field also can be altered to give better efficiency, if the management decides so. Though the effect of topography and surface conditions can not be eliminated altogether, they can be modified to some extent to reduce their adverse effect on the field efficiency. Similarly, what type of terrace layout or other soil conservation practices, the field should have also depends to a great extent on the management. Method and speed of operation can be decided by the management and the operator depending upon the situation.

The above discussion indicates that though different parameters affect the field efficiency in their own way, management is the most important parameter, which can influence all other parameters in its favour. However, for this, the management has to be well versed with the cause and effect of different parameters and use discretion in most judicious way, considering the over-all and long range effect on the production system as a whole and not only the field efficiency.

Conclusions

Based on the discussion presented in this report, the following conclusions are drawn :

1. From tractive performance point of view, the crawler tractors perform best at low speeds (below 6.5 kmph), while the wheel tractors perform best at higher speeds. The tractive efficiency of 4-wheel drive tractor is much higher compared to 2-wheel drive tractor. The drawbar horse power available from a 2-wheel drive tractor in field conditions will be about 50-60% of the brake horse power.

2. It is practically impossible to use the full width of machines in field without occasional skips. In tillage machines, 90% of their rated width can be effectively used.

3. Field time lost in minor repairs and adjustment of the machinery depends on the condition of machine and also type of operation. For most tillage operations this loss was found to be 2-7% of the total field time.

4. Considerable amount of field time is lost in flow of materials to and away from the machine. The loss depends on the type of operation as well as method adopted to supply/remove the materials. Field losses of 10-20% have been reported in case of grain drills and 4-17% in case of trailed combines.

5. Field efficiency increases with increase in the length-width ratio and size of plots for all the operations. This trend holds good, even if head lands are not to be worked out. The rate of increase in the efficiency is higher in the beginning and reduces considerably beyond a length-width ratio of 3:1. Under

Indian conditions of small holding and multiple cropping, one hectare plot with a length-width ratio 3:1 seems to be the appropriate.

6. More work can be accomplished on flat land than slopy land. Undulated and rough surface condi tions of field, particularly in turning areas, adversely affect the field efficiency. Turning time may increase by 18-28% on rough surface compared to smooth one.

7. Method of operation affects the idle run and turning time, which in turn influences the field efficiency. These losses vary from 8-16% of the total field time. For general ploughing operation, land method with varying idle run and for other tillage operations, land method with constant idle run are most efficient. However, the theoretical equations can be used to predict the field efficiency in actual situation and the method that gives the maximum efficiency can be adopted.

8. Speed of operation does not affect the field efficiency significantly. However, higher speed helps to get better pulverisation in light soils. It also helps in timely operation. The operator should select only such speed, at which they can effectively control the machine without compromising the safety as well as the quality of the work.

9. Terraces tend to decrease the field efficiency. Parallel terrace fields give better field efficiency than conventional terraces. Long rows across the terraces give about 20% saving in field time compared to relatively short rows along the terraces.

10. Turning at the end of the field accounts for 5-10% of the total field time. Minimum turning time results when the turning area is smooth and wide enough to allow an easy semi-circle turn.

11. Skill of the operator and enlightened management play very important role in influencing the field efficiency.

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Productivity in Rice Milling Industry

B. K. ARORA

Rice Milling Industry in India has a long history of development. It is only to be looked as an industry but a socio-economic module with which several social and cultural sentiments are associated. Although economic value of the activity cannot be completely over-looked yet any productivity measures have to necessarily take into account all the aspects of the problems rather than a phase in isolation.

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Most commonly productivity has been defined as the ratio of output to input which measures the efficiency of the system to convert resources into the utilities or products. But this represents only the static meaning of productivity, in fact, over a period of time, productivity means continuous improvement of the above ratio for better and better utilization of the resources. It means elimination or reduction of wastages of all types and forms. Underutilization or low efficiency of the resources may be due to inappropriate technology, old equipments, wrong location of industrial unit, faulty layout of building or equipment, misplacement of personnel, governmental policies etc. The concept of productivity aims at making better and better use of resources to get maximum out of these on a continuous basis.

Another aspect of productivity is that it is always related to the objectives. All productivity measures are usually directed to fulfil certain objectives. These may relate to industrial unit, industrial group, region or national objectives. Sometimes, the objectives may mutually interfere with one another. For example, a rice mill manager may be interested in maximum returns without earing for the yields whereas nationally it may be desirable to increase milling yields. Similarly eating habits of the people may be against the national objectives of providing more nutritions. Under such conditions productivity brings coherence among the conflicting objectives.

Characteristics of RM Industry

As mentioned earlier, to affect any productivity improvement coherent with the objectives, it is essential to understand the nature of industry and its beneficiaries. In this context, following paragraphs give location of the industry, capacity utilisation, employment pattern, ownership pattern and linkages of the industry.

1. Location of Industry vis-a-vis production areas

Tables 1 and 2 at the end of this paper reveal that while the production is maximum in West Bengal, the largest number of mills are in Tamilnadu. Similarly Kerala, although contributes only 2.5 percent to the paddy production, nearly 15 per cent of the mills are located in the state. The locational disequilibrium has resulted in large movements of materials from one area to another area causing strains on productivity.

2. Type of Units

In spite of the fact that the third generation technology has proved its economics, large number of huller mills continue to operate. Table 2 indicates that 80 per cent of mills, in the country, even today, employ the technology which has become outdated in many of the countries. Moreover the concentration of these mills is largest in Tamilnadu, Kerala, Karnataka, Maharashtra and Andhra Pradesh which are traditionally rice consuming areas. Modern mills have mostly emerged in northern and eastern states. Thus there are definite patterns of adoption of technology.

3. Capacity Utilization

Although state-wise capacity utilization figures are not available, yet the rough estimates at the national level reveal a capacity utilisation of not more than 38 per cent. This has been worked out on the basis of number of mills and the total paddy available for milling. Capacity utilization is particularly lower in case of states which have higher number of huller mills.

4. Employment Pattern

Rice Milling industry employs nearly 4.5 lakh persons. About 50 per cent of this labour force is employed

APPENDIX 1

Production of Paddy and Rice (1980-81)

State	Area (000 ha)	Production of rice (000 tonnes)	Production of paddy (000 tonnes)	Percent of All India Production
Andhra Pradesh	3607.3	7134.2	10700.7	13.39
Assam	2275.0	2522.8	3976.8	4.97
Bihar	5490.5	5476.0	8213.9	10.28
Gujarat	477.5	556.6	835.0	1.04
Haryana	472.0	1228.0	1842.0	2.30
Himachal Pradesh	109.4	96.9	145.4	0.18
Jammu & Kashmir	264.6	546.4	825.3	1.03
Karnataka	1084.7	2210.0	3345.0	4.18
Kerala	785.0	1291.8	1966.2	2.46
Madhya Pradesh	4797.5	4001.9	6002.9	7.51
Maharashtra	1503.8	2360.6	3369.4	4.22
Manipur	188.6	273.0	409.5	0.51
Meghalaya	99.0	132.6	212.0	0.27
Nagland	101.6	91.4	152.3	0.19
Orissa	4199.0	4331.0	6496.5	8.13
Punjab	1178.0	3223.0	4834.5	6.05
Rajasthan	170.1	149.8	224.7	0.28
Tamilnadu	2112.0	3975.0	5933.0	7.42
Tripura	287.6	390.0	585.6	0.73
West Bengal	5175.7	7465.6	11,198.4	14.01
Uttar Pradesh	5180.6	5440.0	8160.0	10.22
Andaman & Nicobar	11.9	18.5	27.8	0.03
Arunachal Pradesh	75.1	88.8	133.2	0.17
Dadar & Nagar Haveli	10.5	13.6	20.2	0.03
Delhi	3.4	7.8	11.7	0.01
Goa, Daman Diu	52.7	116.9	175.4	0.22
Mizoram	29.0	28.3	42.4	0.05
Pondichery	31.2	60.5	90.7	0.12
ALL-INDIA	39773.3	52,231.0	79.929.9	100.00

Source : Directorate of Economics and Statistics, New Delhi.

APPENDIX 2

State-wise Distribution of Rice Mills India

S. No.	Name of the State/Union Territory	Hullers	Shellers	Huller-cum Shellers	Modern/ Modernised Rice Mills	Total
1.	Himachal Pradesh	944	—	—	—	944
2.	Punjab	2401	55	—	499	2955
3.	Haryana	1077	273	—	273	1623
4.	Uttar Pradesh	5199++	473	103	703	6497
5.	Rajasthan	209	40	4	15	368
6.	Madhya Pradesh	4951	212	244	28	5435
7.	West Bengal	205	3	2	430	640
8.	Assam	466	Information awaited	2163	103	2732
9.	Meghalaya	34	Nil	7	Nil	41
10.	Manipur	71	—	97	1	169
11.	Sikkim	17	Nil	Nil	Nil	Nil
12.	Bihar	4749	63	9	51	4872
13.	Andhra Pradesh	5643	1061	3696	601	11001
14.	Orissa	3050	34	220	674	3978
15.	Madras	3052	343	163	82	3640
16.	Tamil Nadu	14528	34	110	63	14735
17,	Maharashtra	5128	303	488	17	5931
18.	Karnataka	6778	567	728	141	8214
19.	Kerala	12911	2	1	11	12925
20.	Nagaland	Nil	Nil	Nil	Nil	Nil
21.	Pondicherry	199		12	Nil	211
22.	Delhi	42	Nil	Nil	Nil	42
23.	Chandigarh	22	Nil	Nil	2	24
24.	Goa, Daman & Diu	587	Nil	Nil	Nil	587
25.	Dadra & Nagar Haveli	16	3	—	—	21
26.	Lakshadweep	Nil	Nil	Nil	Nil	Nil
27.	Andaman & Nicobar	142	12	39	5	198
28.	Mizoram	(+)	Nil	Nil	Nil	—
29.	Arunachal Pradesh	124	—	68	—	192
	GRAND TOTAL	72,816	3,480	8,154	5,677	91,154

Source : Department of Food, Ministry of Agriculture & Irrigation, Government of India, New Delhi.

in the huller mills. Most workers in the huller mills are unskilled without any professional training. Even in the modern mills, which require higher levels of technical skills, the art of running mill is learnt through the informal learning methods and rarely through a formal professional training course.

5. *Ownership Patterns*

The major portion of the industry is controlled by the private enterpreneurs. The efforts to run the mills in public sector and cooperative sector has not been very successful. The huller mills are exclusivery run in the private sector. The small hullers operating on custom milling are mostly 'One man show'. In several cases, the single hullers are operated only as a supplementary business.

6. *Producer Processor & Consumer Relationship*

In case of large mills undertaking commercial milling operations, the relationships with the producers are more pronounced whereas relationship with the consumers are not so evident. But in case of small mills operating on custom milling, the bondage with consumers is more predominant. But the whole system involves large number of beneficiaries with several interlinkages.

The above discussion leads us to the following :

(a) Rice Milling industry is a highly dispersed industry with large number of units.

(b) The industry has a large installed capacity and the capacity utilisation is low.

(c) A major portion of the industry employs equipments and tools which are obsolete.

(d) Fate and fortune of large number of people is associated with the health of the industry.

(e) The industry mainly being in the private sector has to be run as a profit oriented industry.

(f) The industry does not exist in isolation but interlinkages exist between other activities.

(g) The industry is mostly inhabited by persons who have little professional training in the area of rice milling.

Productivity Needs

Thus while planning any productivity measure for the industry the following needs of the industry are to be considered.

(a) Productivity measures do not make the present equipment completely redundant.

(b) Productivity measures do not reduce the employment in the industry.

(c) Productivity measures do not disturb badly the linkages between processing and allied systems.

(d) Productivity measures take due note of economics of the milling operations.

Considering the national objectives, design of any new system for productivity improvements should necessarily consider.

(a) Increasing yield of milling operations.

(b) Improving nutritional status of product.

(c) Reducing energy requirements of the process.

Productivity Measures

Productivity measures to fulfil the above needs can both be technological as well as managerial. While the technological measures refer to change in the equip ments and techniques of processing, managerial measures include the operational methods of combining resources. While most technological measures are one time improvements the managerial measures provide a scope for continuous improvements in the use of resources. Besides technological measures mostly require bulk physical investments whereas managerial measures call more for using the ingenuity of person and less in terms of physical investments. Nevertheless, it is important to use both the measures for affecting productivity improvements.

Technological Measures

The technological measures include the changes in system of parboiling, drying, dehusking, polishing and grading of paddy or rice. There are possibilities of improving the transportation handling and storage system of paddy and rice. By-products utilisation is another area which can signficantly improve the profitability of rice mill and reduce pollution.

New methods of parboiling not only help in increasing the out-turn of rice but also reduce the process time, improve the nutritional quality of rice, reduce breakage, provide better by-products, reduce energy requirements and eliminate objectionable odours from the processed rice. Various new methods of parboiling are already in vogue and selecting an appropriate one for the mill is not a different task.

Most of the milling units in the country practice sun drying which results in uneven drying, losses by birds and rodents, work stoppages during cloudy or rainy days, wetting of grains during sudden showers, soiling of wet grains and huge cost on handling of material. The mechanical dryers to meet the requirements of rice mills have already been developed in the country and these provide a ready solution to many of the existing problems of drying of the paddy.

Technological innovations have revolutionized the paddy milling process throughout the world. New methods of dehusking and polishing were introduced in our country in 1964 through a Pilot Project by Government of India and Ford Foundation considering the benefits of new technology. Even the compulsory modernisation of the milling process was introduced through a central legislation. A number of units have come up in the country based upon the new technology. However, typical socio-economic constraints of the small units have come in the way of their adopting the new technology. Efforts are already on foot to meet the equipment requirements for modernisation of these small units.

Significant losses and deteriorating in quality takes place during transport, handling and storage of paddy and rice. Storage and handling at traders/rice mill godowns leave much to be desired. Storages are not built for the purpose and any building is considered good for storage. The scientific storage practices are usually not followed. Scientific storage facilities at collection points and rice mills can significantly improve the productivity of a rice mill.

Another area which has received lot of attention recently is the by-product utilisation. The two by-products namely husk and bran has potential for use as material for manufacture of large number of value added products. In addition, husk has high calorific value and can be used as fuel for industrial boilers, furnaces and domestic/kitchen purposes. The rice bran is a good source for industrial and edible grade oil. Proper utilisation of by-products can bring additional returns to the rice mills as well as meet requirements of material for product manufacture. A proper utilisation strategy for by-products is essential for improving the productivity of the industry. The technology to achieve this already exists in the country. A planned and well co-ordinated effort is needed for better utilisation of husk and bran.

Managerial Measures

The most important resource of an organisation is the people. Productivity of an organisation depends to a greater extent on the knowledge, skill and experience of the people in handling men and machines. Large number of managerial tools are available with the management specialists, which if made use of can bring up the managerial efficiency of the organisation. Some of the techniques are production planning and control, work study, cost control and reduction, budgetary control, statistical quality control, performance appraisal, materials management and inventory control, routing and scheduling value analysis, office management, plant layout and material handling, maintenance planning and control etc. An appropriate selection and use of their techniques by the people in the organisation can greatly improve the productivity of the rice milling industry. As most managers in the milling industry are not familiar with these techniques, their training through illustrative case studies is the first and foremost task to be accomplised for achieving productivity enhancement.

It is not only the managers but people at all levels that require training depending upon their nature of job, performance of the job and future expectations from them. The training programme should be designed specifically to meet the requirements of the group. Some of major hurdles in the development of the industry can be solved if the people involved are enlightened.

Besides training of the personnel, it is important to monitor and evaluate the performance of the industry. The gaps should be properly diagnosed and measures taken for improving performance. Diagnosis of regional imbalances, local imbalances and unit level problems can help in evolving solutions of poductivity problems. The plight of the industry, as it exists today, can be well known from the fact that no directory or national register giving the details of the industry is available. A national register containing the important information on performance of the industry in various states/regions is the immediate need of the industry. This can be the starting point far preparation of future developmental plans for the industry as well as organising efforts for improving peformance of the industry.

Institutional Measures

Institutional measures will include strengthening credit facilities for modernising the rice mills, marketing facilities for paddy and rice, research and development facilities for developing appropriate equipments, training and extension facilities for training rice mill personnel, and entrepreneurship development for utilising by-products. The rationalisation of levy policy, enforcing quality control on equipment manufactures, rationalisation of standards for paddy and rice, licensing policy for establishment of new mills, incentives and subsidies for modernisation of smal mills are some of other policy measures which has a direct influence on the productivity of the rice milling industry.

There may be several other factors which may influence the environment under which rice milling industry operates. The problems and needs of the industry has to be looked from a system point of view rather than looking into the problems in isolation. Solutions to one problem may lead to emergence of another problem if the total environment is not taken care of. The efforts have to made on technological, and institutional front to improve the productivity of the industry.

Since last three years National Productivity Council has been continuously and consistently making efforts to improve the productivity of rice milling industry. It has been keeping liaison with the various agencies responsible for productivity promotion for rice milling industry. At its own, it has been organising activities to promote and extend the new ideas to the large number of beneficiary. It is also helping Department of Food, Government of India to carry through the modernisation drive for rice milling.

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Sugar Industry in Crisis

DR. BADAR ALAM IQBAL

The sweet agent has become one of the important items of consumption of modern society. It is interesting to note that some time it faces a problem of scarcity and some time the problem of plenty. The main objective of this paper is to analyse different facets of this agent both at international and domestic levels. The study also includes a discussion on the major constraints standing in the way of growth and development and suggests suitable measures for attaining stability in sugar industry.

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India is the biggest producer of sugarcane in the world. The total area under the cultivation of crop is around 33,00,000 hectares having annual production of nearly 183,600,000 tonnes accounting for more than 23 per cent of the world acreage and production. Table I indicates trends in acreage production and productivity of sugarcane in major producing countries of the world in 1979-80.

Table I

Area, production and productivity in selected nations in 1979-80

Country	Average (000 Hect.)	Production (000 Tonnes)	Productivity (Tonnes)	% to total A	% to total P
India	3,300	1,81,600	56.4	23.2	23.2
Brazil	2,413	1,30,223	52.6	17.4	16.5
Cuba	1,246	67,600	53.3	9.0	8.5
China	675	48,198	69.8	4.9	6.0
Mexico	480	35,600	72.0	3.5	4.4
USA	327	24,870	81.0	2.2	3.1
Australia	258	21,500	83.9	1.9	2.7
World (including others)	13,861	7,81,300	56.9	100.0	100.0

Source : World Survey, 1981-82.

Data set out in table I reveal that India ranks first both in acreage and production in the world and accounting for 23.2 and 23.2 percent respectively. But its position so far as yield is concerned, comes fifth. Brazil is the second largest producer of sugarcane in the world constituting 17.4 and 16.5 per cent of the global area and production respectively and has sixth place in productivity. While Cuba holds third place with 9 and 8.5 per cent of the same. It ranks seventh in yield per hectare. It is interesting to note that these three countries together account for nearly 50 per cent of the world acreage and production. The other countries of the world namely: China, Mexico, the USA and Australia form 5 and 6 per cent, 3.5 and 4.4 per cent, 2.2 per cent and 3.1 per cent and 1.9 and 2.7 per cent of the global area and production respectively. In yield per hectare Australia ranks first with a figure of nearly 84 tonnes per hectare followed by the USA with 81 tonnes, Mexico with 72 tonnes and China with nearly 70 tonnes. It is surprising to note that the major producing countries namely India, Brazil and Cuba has low productivity per hectare, while minor producing nations such as China, Mexico, the USA and Australia have higher degree of yield per hectare. It is depressing to note that India's yield per hectare of sugarcane is even below the average of the world as a whole. Hence, the need of the day is to enhance productivity to a maximum possible extent by adopting new methods of production as well as new varieties of sugarcane. In the light of the above we shall now turn to analyse the national sugar economy since independence.

National Scene

Few years back Indian sugarcane economy was facing the problem of scarcity. Now a days, it is facing a crisis of plenty. This state of affairs is because of the 1981-82 crushing season (October-September) when, output of sugar recorded an all time figure of 84.4 lakh tonnes. This crisis of plenty is not new to our sugar industry. Table II shows trends in acreage, production and productivity of sugarcane between 1950-51 and 1981-82.

Table II

Trends in area, output and productivity 1950-51 to 1981-82

Year	Area (Lakh hectares)	Production (Lakh tonnes)	Productivity per hectare/ tonne
1950-51	17.07	692.20	40.5
1955-56	18.46	726.32	39.3
1960-61	24.13	1,400.01	45.7
1965-66	28.36	1,239.90	43.7
1970-71	26.15	1,263.68	48.3
1975-76	27.62	1,406.04	50.9
1980-81	26.50	1,540.00	56.8
1981-82	32.89	1,836.60	54.7

Source : Indian Sugar, New Delhi, Various issues.

Statistics given in table II show that total acreage under sugarcane cultivation went up by more than 94 per cent i.e. from 17 lakh tonnes in 1950-51 to nearly 33 lakh tonnes in 1981-82. Similarly, the total production of sugarcane has gone up from 692.2 lakh tonnes in 1950-51 to 1,836.6 lakh tonnes in 1981-82, indicating an over all rise of more than 165 per cent. This all shows that the rate of increase in production is many times higher than the rate of increase in acreage. This is because of a variety of reasons. By and large the weather has helped in sustaining the tempo of production. Similarly, extensive cultivation resulting higher production and productivity per hectare and the rate of application of fertilisers especially urea, which was on an unprecedent scale are responsible for the rise in production. But it is important to note that the rate of increase in yield per hectare is far less than the rate of increase in acreage and output. Therefore, it is obvious that the rate of yield per hectare and the rate of acreage under cultivation will have to be enhanced if India wants to remain as the biggest producer of sugarcane in the world. For this act, the major producing states should make utmost efforts for boosting yield per hectare by providing seeds of good quality as well as disease free seeds, proper telling of cane formation, plants protection schemes and distribution of chemical fertilisers. According to an estimate made by Planning Commission, the demand for sugarcane would be 207 million tonnes in 1982-83. Thus, in order to attain the target the area under cultivation as well as productivity should get top priority.

By and large the performance on production horizon has been satisfactory which is evident from the table III showing compound growth rate of acreage, production and productivity.

Table III

Trends in compound growth rate in area, production and Productivity from 1949-50 to 1979-80

Period	Growth rate (per cent per annum)		
	Area	Production	Productivity
1949-50 to 1964-65	3.26	4.59	1.29
1967-68 to 1979-80	2.96	3.80	0.78
1960-61 to 1979-80	1.48	2.46	0.79

Source : Indian Sugar, New Delhi.

State-wise analysis

The main sugarcane growing states are Uttar Pradesh, Maharashtra, Tamil Nadu and Karnataka. These three states together accounted for more than 73 per cent of the total output in 1980-81. Trends in acreage and production of sugarcane in major producing states between 1950-51 and 1980-81 can be seen from table IV.

Data set out in table IV show that India's total acreage under sugarcane cultivation went up from 17.07 lakh hectares in 1950-51 to 26.48 lakh hectares in 1980-81, indicating an over all rise of nearly 55.2 per cent. Uttar Pradesh recorded a rise of nearly 35 per cent in area under cultivation of crop i.e. from 10.14 lakh hectares to 13.65 lakh hectares during the same period. Tamil Nadu accounts for a rise of 172 per cent i.e. from 0.50 lakh hectares to 1.36 lakh hectares. The acreage in case of Andhra Pradesh went up by nearly 88 per cent i.e. from 0.72 lakh hectares in 1950-51 to 1.35 lakh hectares in 1980-81. Maharashtra recorded the maximum increase of nearly 308 per cent i.e. from 0.65 lakh hectares to 2.56 lakh hectares during the period under reference. The second highest increase witnessed in case of Karnataka i.e. a rise of more than 271 per cent from 0.42 lakh hectares to 1.56 lakh hectares. But the acreage under crop cultivation went down considerably in case of Bihar. Punjab and

Table IV

State-wise area and output of sugarcane 1950-51 to 1980-81

Name of the state	1950-51		1960-61		1970-71		1980-81	
	A	P	A	P	A	P	A	P
U.P.	10.14	400.30	13.63	546.72	13.45	545.19	13.65	642.42
Tamil Nadu	0.50	37.60	0.81	63.11	1.35	104.43	1.36	135.52
A.P.	0.72	49.10	0.91	57.48	1.20	91.22	1.35	101.85
Maharashtra	0.65	53.95	1.55	120.89	2.17	147.70	2.56	235.93
Bihar	1.66	43.60	1.85	70.38	1.62	62.09	1.12	34.98
Punjab	1.51	46.60	2.69	105.70	1.28	52.70	0.72	39.76
Haryana	—	—	—	—	1.55	69.80	1.55	46.65
Karnataka	0.42	23.80	0.72	51.84	0.97	84.83	1.56	127.15
All India	17.07	692.20	24.13	1105.44	26.151	263.68	26.48	1505.22

Note : Figures are in lakhs.

Source : Indian Sugar, New Delhi.

Haryana. The maximum fall recorded with regard to the Punjab i.e. more than 52 per cent, from 1.51 lakh hectares to 0.72 lakh hectares. Bihar witnessed a decline of nearly 38 per cent i.e. from 1.66 lakh hectares in 1950-51 to 1.12 lakh hectares in 1980-81. Haryana recorded the lowest possible fall in acreage under cultivation of sugarcane i.e. nearly 26 per cent from 1.55 lakh hectares to 1.15 lakh hectares. This state of affairs was due to shift in favour of the cultivation of other commercial crops because of the unremunerative prices of cane. It is interesting to note that though Uttar Pradesh has got the maximum area under cultivation of sugarcane, the increase recorded is the lowest. While in case of Karnataka the lowest is the acreage under cultivation, the rise in the area is next to Maharashtra which showed a maximum rise. It is also interesting to note that the rate of increase in as a whole is much lesser than acreage of the country the rate of rise in case of Maharashtra, Karnataka. Tamil Nadu and Andhra Pradesh, whereas it is more than the rate of increase in case of Uttar Pradesh.

Table IV further reveals that, country's total production of sugarcane went up by nearly 118 per cent i.e. from 692.20 in 1950-51 to 1505.22 lakh tonnes in 1980-81. Whereas, the total output of crop in Uttar Pradesh showed a rise of nearly 61 per cent i.e. from 400.30 lakh tonnes to 642.40 lakh tonnes during the period under reference. Tamil Nadu's production went up from 07.60 lakh tonnes to 135.5 lakh tonnes, i.e. an over all rise of more than 260 per cent during the period under review. The output of sugarcane in case of Andhra Pradesh showed a rise of more than 107 per cent i.e. from 49.10 lakh tonnes in 1950-51 to 101.8 lakh tonnes in 1980-81. Maharashtra witnessed the second maximum record rise in the production of sugarcane between 1950-51 and 1980-81 i.e. an over all increase of more than 337 per cent (53.95 lakh tonnes to 235.9 lakh tonnes) Similarly Karnataka recorded a rise of 434 per cent in the production of sugarcane which is the highest among all the states of the country i.e. from 23.80 lakh tonnes to 127.10 tonnes. The other major producing states of the country namely Bihar, the Punjab and Haryana recorded a considerable decline in the production of sugarcane during the period under review. Bihar, the Punjab and Haryana showed a decline of nearly 20 per cent, 15 per cent and more than 33 per cent i.e. from 43.60 lakh tonnes to 34.90 lakh tonnes, 46.60 lakh tonnes to 39.70 lakh tonnes and 69.80 lakh tonnes to 46.6 lakh tonnes respectively. It is important to note here that the rate of decline in case of acreage is more alarming than the rate of decrease in production. This all shows that the yield per hectare has also come down to a considerable extent. Table V shows a comparative share of acreage and production of sugarcane in major producing states of the country between 1950-51 and 1980-81.

It is seen from the Table V that in 1950-51 the share of Uttar Pradesh in country's total acreage was 59.4 per

Table V

Comparative share in area and output of major producing states 1950-1951 to 80-81

State	1950-51		1980-81		% share in the total			
	Area Lakh Hect.	Output Lakh Tons	Area Lakh Hect.	Output Lakh Tons	Area 1950-1980	1951-1981	Output 1950-1980	1951-1981
U.P.	10.14	400.30	13.65	642.40	59.4	51.7	58.0	42.5
A.P.	0.72	49.10	1.35	101.80	4.2	6.0	4.2	6.8
Tamil Nadu	0.50	37.60	1.36	135.5	2.9	5.0	2.9	9.0
Maharashtra	0.65	53.95	2.56	235.9	9.7	9.7	3.8	15.7
Bihar	1.66	43.60	1.12	34.9	9.7	4.7	9.7	2.3
Karnataka	0.42	23.80	1.56	127.1	2.4	5.9	2.8	8.5

Source : Indian Sugar, New Delhi various issues.

cent and ranks first. Bihar comes next to Uttar Pradesh and its share in the total area was 9.7 per cent. Andhra Pradesh holds third place and the share of the same was 4.2 per cent. Maharashtra had fourth place with a figure of 3.7 per cent, followed by Tamil Nadu 2.9 per cent and Karnataka 2.4 per cent. Similarly, in 1980-81, though the share of Uttar Pradesh in the country's total area under cultivation has declined to 51.7 per cent, from 59.4 per cent, but she maintained her place i.e. first. Maharashtra outpaced Bihar and emerged second with a share of 9.7 per cent. Tamil Nadu's share in the total area went up to 5.1 per cent. Karnataka which was in the bottom in 1950-51 become third biggest state of the country in regard to acreage and the share of the same went up to 5.9 per cent, followed by Andhra Pradesh with a figure of 5.0 per cent, Bihar 4.7 per cent. This means that in 1980-81 the share of Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh showed a rising trend so far as acreage under sugarcane cultivation is concerned, whereas the share of Uttar Pradesh and Bihar which were considered as the home of sugarcane has declined considerably.

Likewise, in 1950-51, the share of Uttar Pradesh, Andhra Pradesh, Tamil Nadu, Maharashtra, Bihar and Karnataka was 58.0 per cent, 4.2 per cent, 2.9 per cent, 3.8 per cent, 9.7 per cent and 2.8 per cent respectively. While in 1980-81 the share of these states in the country's total production of sugarcane was 42.5 per cent, 6.8 per cent, 9.0 per cent, 15.7 per cent, 2.3 per cent and 8.5 per cent. This all shows that the share of Andhra Pradesh, Tamil Nadu, Maharashtra and Karnataka has gone up during the period under review. While the share of Uttar Pradesh and Bihar showed a considerable decline in production of cane. In 1950-51, Uttar Pradesh ranked first. Bihar was the second and Andhra Pradesh was the third biggest producer. Where as in 1980-81, Uttar Pradesh, Maharashtra and Tamil Nadu hold first, second and third positions respectively. This analysis shows that there has been a shift in regard to acreage and production of sugarcane in major producing states of the country.

Sugarcane cultivation is subjected to a number of constraints which have hampered the growth and development of sugar industry in recent years. The first and foremost problem is that India achieved only a limited progress in the field of breeding varieties suited to agronomical environment and the results are not very satisfactory in evolving early maturing varieties of both the plant and the ratoon crop.

The fixation of prices of sugarcane according to weight is another important problem associated with the cultivation of sugarcane in India. According to mills point of view, it is the sugar content rather than weight that really matters. It is therefore, essential to promote and develop only those varieties of cane which serve both the purposes. Added to this, the utilisation of sugarcane output does not loom large from the cultivation view-point. They always perfer those varieties which bring a reasonable return to them without keeping the consideration whether they are suited for sugar manufacture or making gur and khandsari. Because of this reason the degree of utilisation of output varies considerably year to year.

The third important handicap is that the cane development programme which has confined its attention to the supply of disease-free nutrient rich seeds only to mill areas. These areas have also the benefits of adequate supply of fertilisers, irrigation facilities and the plant protection measures. But sugarcane cultivation in other areas which constitute more than 75 per cent of the total acreage under sugarcane cultivation has suffered a lot due to the policy of neglect. As a result, there has been sharp fluctuations in area and output between 1950-51 and 1980-81. It is not fair on the part of the Central Government to focus attention only to mills area. The Govt should also give due attention to non-mill areas so that there could be an over all growth and development of sugar economy.

Another most important problem of sugarcane economy is ratooning which is also common to all growing states of the country. But this problem is more serious in the North-region which accounts for more than 30 per cent of the total acreage and covers Bihar and Uttar Pradesh states. As a result, the share of these two states in the country's total area and production has come down to a considerable extent (table V). Ratooning is necessary to curb the cost of cultivation and the same is popular among the growers. Since this crop matures early, it feeds the sugar industry till the arrival of the main crop. But indiscriminate ratooning and the repeated use of the same material and double and triple ratooning have been responsible for plant disease as well as for lowering productivity. Recently, the Indian Council of Agricultural Research (ICAR) has brought out a hand book on agriculture. According to this handbook, the first ratoon is only recommended in most of the states. The second, third and fourth ratoon are not at all advisable due to the risk of pests and diseases accumulating and breaking out into the next crop.

Lastly, although the Agricultural Prices Commission (APC) have recommended a rise of Rs. 2.50 to Rs. 15.50 per quintal in cane price, the statutory minimum price of cane for the session 1982-83 has been kept unchanged at Rs 13 per quintal and linked it to a recovery of 8.5 per cent. This step may add fuel to fire and the handicap of poor profitability of the sugar industry would become more alarming. It is heartening to note that Central Government is considering the imposition of a maximum price for cane to be fixed at Rs 18 a quintal. It is hoped that if the proposal of maximum price be implemented effectively, there are no doubts that it would keep down the costs of sugar industry to a considerable extent during the session of 1982-83.

Sugar Economy

Indian sugar economy has been facing a crisis of plenty since the crushing season of 1981-82. In this year the output of sugar recorded an all-time high figure of 84.4 lakh tonnes. According to the latest date available on production horizon, the year 1982-83 will record sugar output between 75 and 80 lakh tonnes. This means, nearly 112 lakh tonnes of sugar would be available during 1982-83, as the stock of sugar at the end of September 1982 were reported about 32 lakh tonnes. As against this figure, the total offtake of sugar during 1982-83 is estimated at 62 to 67 lakh tonnes, resulting in huge stocks of between 45 and 50 lakh tonnes valued at Rs 1.500 crores by the end of 1982-83. This phenomenon is not new to sugar industry of India. It has become a regular feature resulting in violent cyclical fluctuations in production, prices and the availability of sugarcane. This all calls a well integrated policy keeping mind these problems.

It is surprising to note that that within the period of one year Indian sugar scene has undergone a seachange and this sweeting agent has now emerged as the most volatile. Table VI shows trends in number of sugar factories, working capacity, can crushed, sugar produced and recovery of sugar between 1950-51 and 1980-81.

Table VI

Year	No. of Sugar factories	Average actual capacity (tonnes) per 24 hrs	Total cane crushed ('000 tonnes)	Recovery of sugar % cane	Total sugar produced ('000 tonnes)
1950-51	138	873	11,147	10.03	1,118
1955-56	143	1012	19,241	9.83	1,829
1960-61	174	1168	31,109	9.74	3,028
1965-66	200	1249	36,404	9.68	3,532
1970-71	216	1359	38,204	9.78	3,740
1975-76	253	1569	41,849	10.19	4,261
1980-81	314	1725	51,641	9.98	5,140

Source : Indian Sugar, New Delhi.

It is evident from the table VI that number of sugar factories went up by more than 128 per cent i.e. from 138 in 1950-51 to 314 in 1980-81. Similarly, average capacity has gone up from 873 tonnes per 24 hours in 1950-51 to 1725 tonnes per 24 hours in 1980-81, showing an over all rise of more than 96 per cent. Likewise, total cane crushed has gone up by more than 363 per cent i.e. from 11,147 thousand tonnes in 1950-51 to 51,641 thousand tonnes in 1980-81. Similarly, total sugar produced has increased from 1,118 thousand tonnes in 1950-51 to 5,140 thousand tonnes in 1980-81, showing an over all rise of nearly 360 per cent. This all shows that the rate of increase in total sugar produced is much higher than the rate of increase in the average capacity that is why recovery of sugar as percentage of cane has declined marginally i.e. from 10.03 per cent in 1950-51 to 9.98 per cent in 1980-81. It is also interesting to note that the rate of increase in total cane crushed is slightly higher than the rate of increase in the total sugar produced. Table VII shows trends in production and consumption of sugar in India between 1950-51 and 1980-81.

Table VII

Trends in Production and Consumption of sugar 1950-51 and 1980-81

Year	Production (Million Tonnes)	Consumption (Million Tonnes)	% increase or decrease over 1950-51	
			P	C
1950-51	1.1	0.8	—	—
1955-56	1.6	1.2	45.4	50.0
1960-61	3.0	2.0	172.0	150.0
1965-66	3.5	2.7	218.0	262.0
1970-71	3.7	4.0	236.0	400.0
1975-76	4.2	3.6	281.0	350.0
1980-81	5.1	4.9	363.6	512.5
1981-82	8.4	5.6	663.6	600.0

Source : Indian Sugar, New Delhi.

Data given in table VII show that India's total production of sugar went up from 1.1 million tonnes to 8.4 million tonnes between 1950-51 and 1981-82, showing an over all rise of nearly 664 per cent. Whereas, India's total consumption of sugar was from 0.8 million tonnes in 1950-51 to 5.6 million tonnes in 1981-82, indicating a rise of 600 per cent. It is also evident that from 1950-51 to 1980-81 the rate of increase in the international consumption was very higher than the rate of increase in production of sugar. While in 1981-82 this trend has become reverse and the rate of increase in production is much higher than the rate of increase in consumption. This state of affairs is due to good crop of sugarcane during 1981-82.

In India sugar factories are confined to rural areas of Uttar Pradesh, Maharashtra, Bihar, Andhra Pradesh, Tamil Nadu, Karnataka and Gujarat. Statewise number of sugar factories operating in the country between 1950-51 and 1980-81 can be observed from table VIII.

Statistics given in table VIII reveal that the number of sugar factories in Uttar Pradesh went up from 57 in 1950-51 to 90 in 1980-81, indicating a rise of nearly 58 per cent. Similarly, the number of sugar in Maharashtra have increased by 413 per cent between 1950-51 and 1980-81 i.e. from 15 to 77. Likewise, sugar factories in Andhra Pradesh showed an over all rise of 170 per

Table VIII

Statewise Number of Sugar Factories in India 1950-51 to 1980-81

States	1950-51	1960-61	1970-71	1980-81
U.P.	67	70	71	90
Bihar	29	29	27	28
Maharashtra	15	27	41	77
A.P.	—	12	19	27
Tamil Nadu	12	8	15	21
Karnataka	1	8	11	23
Total India	138	174	211	314

Source : Indian Sugar, New Delhi.

cent i.e. from 10 in 1955-56 to 27 in 1980-81. The total number of sugar factories in Tamil Nadu went up from 12 in 1950-51 to 21 in 1980-81, indicating an over all rise of more than 75 per cent. The state of Karnataka also recorded a rise of 2200 per cent between 1950-51 and 1980-81 i.e. from 1 to 23. Whereas the state of Bihar showed a marginal decline in number of sugar factories i.e. from 29 in 1950-51 to 28 in 1980-81 a fall of more than 3 per cent. This all shows that the rate of increase in the number of sugar factories is highest in Karnataka. The state of Maharashtra come next to Karnataka and Andhra Pradesh holds third place followed by Tamil Nadu and Uttar Pradesh.

In 1950-51 the share of Uttar Pradesh, Bihar, Maharashtra, Andhra Pradesh, Tamil Nadu and Karnataka in the country's total number of sugar factories in operation was 41.3, 21, 10.8, nil, 8.7 and 0.7 per cent respectively. While in 1980-81. the share of these states in the total number of sugar factories in operation in the same order was 28.7, 8.9, 24.5, 8.6, 6.7 and 7.3 per cent respectively, This analysis shows that the share of Uttar pradesh, Bihar and Tamil Nadu have gone down in total number of sugar factories. Whereas the share of Maharashtra and Karnataka went up during the period under reference. In 1950-51 Uttar Pradesh ranked first. Bihar comes next to Uttar Pradesh and Maharashtra holds third place followed by Tamil Nadu and Karnataka. The state of Karnataka was the lowest in the share. In 1980-81. Uttar Pradesh comes first, though its share in the total went down considerably.

Maharashtra outpaced Bihar and become the second. The state of Bihar holds third place followed by Andhra Pradesh, Karnataka and Tamil Nadu. This all shows that Indian sugar economy has been diversified and the states like Maharashtra and Karnataka have developed this industry on a large scale and paying added attention to the development of such an important industry as compared to other major producing states like Uttar pradesh, Bihar, Tamil Nadu and Andhra Pradesh. Table IX shows trends in statewise production of sugar between 1950-51 to 1980-81.

Table IX

Statewise production of sugar in India 1950-51 and 1980-81

(in lakh tonnes)

State	1950-51	1960-61	1970-71	1980-81
U.P.	6.02	14.27	12.99	12.24
Bihar	2.29	3.85	2.92	1.94
Maharashtra	3.20	5.23	10.55	20.35
Andhra Pradesh	1.00	1.83	2.67	1.63
Tamil Nadu	0.92	1.31	2. 29	4.33
Karnataka	0.20	1.20	2.05	3.70
All India	11.18	30.28	37.40	51.50

Source: Indian Sugar, New Delhi.

An analysis presented in table IX shows that country's total production of sugar went up from 11.18 lakh tonnes in 1950-51 to 51.50 lakh tonnes in 1980-81, indicating an over all rise of naerly 361 per cent. Whereas the total production of sugar in Uttar Pradesh has gone up more than 103 per cent i.e. from 6.02 lakh tonnes in 1950-51 to 12.24 lakh tonnes in 1980-81. But the total production of sugar in Bihar has come down by more than 15 per cent i.e. from 2.29 lakh tonnes to 1.94 lakh tonnes during the period under review. The production of sugar in Maharashtra has increased from 3.20 lakh tonnes in 1950-51 to 20.35 lakh tonnes in 1980-81, indicating an over all rise of nearly 558 per cent. Similarly, the total output of sugar in Andhra Pradesh went up by 63 per cent i.e. from 1 lakh tonnes to 1.63 lakh tonnes during the period under review. The total production of sugar in case of Tamil Nadu showed a rise of nearly 371 per cent i.e. from 0.92 lakh tonnes in 1950-51 to 4.33 lakh tonnes in 1980-81. While the production of sugar in Karnataka state went up by 1750 per cent i.e. from 0.20 lakh tonnes to 3.70 lakh tonnes during the period under reference. The rate of increase in production in case of Karnataka is the highest as compared to the rise in the production of sugar in other major producing states of the country. It is surprising to note that the rate of increase in the production of sugar in some states namely, Uttar Pradesh, Andhra Pradesh is very much low than the rate of increase in the production of sugar in the country as whole. While in regard to other states like Karnataka, Maharashtra, Tamil Nadu etc. the rate of rise in the production of sugar is very much higher as compared to the rise in case of the country as a whole. This all shows that since 1950-51, there has been fluctuations in regard to the production of sugar and the disparities are on the increase. Table X shows the trends in the comparative share of sugar output in major producing states of the country between 1950-51 and 1980-81.

Table X

Comparative Share of Sugar Output in Major producing states

Year	U.P.	Bihar	Maharashtra	A.P.	Tamil Nadu	Karnataka
1950-61	53.3	20.1	10.9	2.1	5.2	1.4
1955-56	53.1	17.2	10.5	7.3	2.7	3.1
1960-61	47.1	12.7	17.6	5.9	4.3	4.1
1965-66	39.0	10.5	21.9	8.4	6.3	4.3
1970-71	34.7	7.8	28.2	7.1	6.1	5.4
1975-76	30.5	4.1	32.3	5.8	6.7	8.2
1980-81	23.7	3.8	40.5	3.2	8.4	7.2

Source: Indian Sugar, New Delhi.

Data set out in table X show that in 1950-51, the share of Uttar Pradesh, Bihar, Maharashtra, Tamil Nadu and Karnataka in India's total production of sugar was 53.3, 20.1, 10.9, 2.1, 5.2 and 1.4 per cent respectively. But in 1980-81, the share of these states in country's total output of sugar was 23.7, 3.8, 40.5, 3.2, 8.4 and 7.2 per cent respectively. This means that the share of Maharashtra, Andhra Pradesh, Tamil Nadu and Karnataka went up during the period under review. Whereas, the share of Uttar Pradesh and Bihar has gone down during the same period. The declining is more alarming in case of Uttar Pradesh. The increase in the share of Maharashtra and Karnataka is more appreciable, while the rise in case Andhra Pradesh and Tamil Nadu is marginal. Table XI shows trends in state-wise production and consumption of sugar in 1980-81.

Table XI

Statewise output and consumption of sugar 1980-81

(lakh tons)

State	Production		Consumption	
	Quantity	% to total	Quantity	% to total
U.P.	12.34	23.96	6.36	12.97
Bihar	1.94	3.76	3.08	6.28
Maharashtra	20.85	40.48	7.50	15.29
A.P.	1.63	3.16	2.98	6.07
Tamil Nadu	4.33	8.40	3.42	6.97
Karnataka	3.70	7.18	2.38	4.85
Gujarat	3.32	6.25	3.58	7.30
Punjab	0.51	0.99	2.59	5.28
West Bengal	0.10	0.20	1.58	3.22

Source : Indian Sugar, New Delhi.

It is evident from the table XI that Maharashtra ranks first in production as well as consumption of sugar, accounting for nearly 41 and more than 15 per cent respectively. Uttar Pradesh comes next to Maharashtra, constituting nearly 24 and nearly 13 per cent of India's total production and consumption of sugar. Tamil Nadu holds third place in production with a figure of 8.4 per cent, while it has sixth place in consumption with a figure of 6.9 per cent. Karnataka has fourth place in production with a share of more than 7 per cent and the same stands eighth in consumption with a figure of nearly 5 per cent. The state of Gujarat ranks third in consumption i.e. 7.3 per cent, followed by Tamil Nadu, Bihar and Andhra Pradesh with a figure of 6.97, 6.28 and 6.07 per cent respectively. Whereas, their share in India's total production of sugar was very low. It is interesting to note that the states like Bihar, Andhra Pradesh, Gujarat, Punjab and West Bengal where were producing small quantity of sugar has better consumption pattern than other major producing states of India such as Karnataka, Tamil Nadu etc. Table XII indicates trends in state-wise average recovery of sugar as well as average duration of crushing (indays) in India from 1950-51 to 1980-81.

Table XII

Statewise average recovery of sugar and duration of crushing (in days) from 1950-51 to 1980-81

State	1950-51		1960-61		1970-71		1980-81	
	S	R	S	R	S	R	S	R
U.P.	100	10.3	170	9.5	148	9.2	101	9.4
Haryana	133	9.8	165	8.9	162	8.7	99	8.4
Maharashtra	117	11.6	166	11.7	164	11.3	145	11.1
Karnataka	123	11.4	179	10.1	129	10.6	99	10.4
A.P.	—	—	154	9.8	100	10.2	73	9.1
T.N.	132	9.4	213	9.0	192	8.9	142	8.7
Pondich.	—	—	304	7.2	135	8.8	157	8.1
Gujarat	—	—	142	10.7	100	10.2	135	9.9
W.B.	57	11.2	103	9.7	83	8.7	33	7.3

Source : Indian Sugar, New Delhi.

Statistics given in table XII show that in 1950-51 the average duration of crushing season was highest in Haryana i.e. 133 days. Tamil Nadu comes next with 132 days, whereas Karnataka holds third place with a figure of 123 days followed by Maharashtra 117 days, Uttar Pradesh 100 days and West Bengal 57 days. But in 1980-81, the picture was quite different and Pondicherry ranks first i.e. 157 days followed by Maharashtra 145 days, Tamil Nadu 142 days, Gujarat 135 days, Uttar Pradesh 101 days, Karnataka 99 days, Haryana 99 days and Andhra Pradesh 73 days. The state of West Bengal was at the bottom of the table both in 1950-51 and 1980-81. The state of Uttar Pradesh maintained its original place i.e. fifth place, while, Pondicherry, Gujarat, Tamil Nadu and Maharashtra outplaced their places and emerged with new places. The rise has been recorded in case of Maharashtra, Tamil

Nadu and Uttar Pradesh. Whereas fall has been recorded in case of Haryana, Karnataka and West Bengal. The maximum decline is witnessed in case of West Bengal.

Similarly, table XII also reveals that there has been a marginal decline in average recovery of sugar in all the states of the country between 1950-51, and 1980-81. When we make a comparison of the same during the period under review, it is emerged that in 1950-51, the state of Maharashtra holds top place with a figure of 11.6 percent among major producing of the country. The States of Karnataka and West Bengal rank second and third places with 11.4 and 11.2 per cent respectively. While Uttar Pradesh comes next to West Bengal with 10.3 per cent followed by Haryana with 9.8 per cent, Tamil Nadu with 9.4 per cent. Likewise, in 1980-81, the state of Maharashtra ranks first with a figure of 11.1 per cent, Karnataka comes next to Maharashtra with a figure of 10.4 per cent and the state of Gujarat holds third place with a figure of 9.9 per cent, followed by Uttar Pradesh 9.4 per cent, Andhra Pradesh with 9.1 per cent, Tamil Nadu with 8.7 per cent, Haryana with 8.4 per cent, Pondicherry with 8.1 per cent and the state of West Bengal.

The foregoing analysis reveals some interesting points which may be pointed out here. Firstly, the Uttar Pradesh remained fourth and third in average duration of crushing season as well as in average sugar recovery during the period under reference. Secondly, the state of West Bengal has the lowest place and most affected state among the major producing states so far as these two phenomenon are concerned. Thirdly, the picture is quite different in 1980-81 so far as average recovery of sugar is concerned.

Table XIII indicates trends in utilisation of sugar cane for different purposes from 1960-61 to 1980-81.

From the table XIII it emerges that the total production of sugarcane went up from 1100 lakh tonnes in 1960-61 to 1505 lakh tonnes in 1980-81, indicating an over all rise of nearly 37 per cent. Similarly, the utilisation of sugarcane for the production of white sugar has gone up from 310 lakh tonnes to 516 lakh tonnes between 1960-61 and 1980-81 i.e. a rise of 66.5 per cent. Likewise, the utilisation of sugarcane for producing seed, feed and chewing went up by 29.4 per cent i.e. from 136 lakh tonnes to 176 lakh tonnes during the same period. The utilisation of sugarcane for the production of gur and khandsari has increased from 653 lakh tonnes to 812 lakh tonnes i.e. an over all rise of 24.3 per cent during the period under review. This analysis shows that rate of increase in the utilisation of sugarcane for the production of white sugar is much higher than the rate of increase in the production of other variables. In 1960-61, the share of white sugar, seed, feed and chewing and gur and khandsari was 28.2, 12. 5 and 59.4 per cent. Whereas, in 1980-81, the share of these three variables in the total utilisation of sugarcane for various purposes was 33.3, 11.7 and 54 per cent respectively. This means that the share of white sugar in the total utilisation of sugarcane has gone up 5.1 per cent. While the share of seed, feed and chewing and gur and khandsari in the total utilisation of sugarcane went down by 0.8 and 5.4 per cent respectively. The decline in case of seed, feed and chewing is marginal. But the decline in regard to gur and khandsari is quite substantial. But the decline in regard to gur and khandsari is quite substantial. But it is interesting to note that gur and khandsari still holds 54 per cent share. Hence, if India wants to stabilise the sugar economy, she should give attractive return to the growers of sugar cane so that there could be lesser degree of utilisation of sugarcane in favour of gur and khandsari.

An Overall View

An analysis of table XIV reveals that there has been cyclical movements in sugarcane and sugar output and these cycles have been categorised into four years cycles. Firstly, between 1965-66 and 1968-69. Secondly from 1969-70 to 1972-73. Thirdly between 1973-74 and 1976-77 and Fourthly, from 1977-78 to 1981-82. It is interesting to note that in all the above mentioned categories the first or second year shows the peak, whereas the third year is the lowest possible point of the output cycle. The area under cultivation and output produced also indicates fluctuations from year to year. But it is important to note that the cyclical movements in them are not so alarmed as in case of sugar output. The wide fluctuations in sugar output are also accompanied by violent fluctuations in sugar prices. It is also evident

Table XIII

Trends in Utilisation of Sugarcane for Different Purposes from 1960-61 to 1980-81

Year	Production of sugarcane (lakh Tonnes)	Cane used for Lakh tonnes			% of sugarcane output utilised for		
		Production of White Sugar	Seed & feed chewing etc.	Gur and Khandsari	Productions White Sugar	Seed & feed chewing etc.	Gur and Khandsari
1960-61	110.0	310.2	136.2	653.6	28.2	12.5	59.4
1965-66	123.9	365.1	146.0	728.7	29.4	11.8	58.8
1970-71	126.3	382.0	151.7	729.9	27.3	11.9	60.8
1975-76	140.6	418.8	166.9	820.3	29.8	11.9	58.3
1980-81	150.5	516.2	176.3	812.7	33.3	11.7	54.0

Source : Indian Sugar, New Delhi.

Table XIV

Trends in production, consumption, exports, off-take, availability, imports and closing stock from 1960-61 to 1982-83

Year	Sugar Output L. Tonnes	Total availability L. Tonnes	Internal consumption L. Tonnes	Exports L. Tonnes	Imports L. Tonnes	Total off-take L. Tonnes	Closing stock L. Tonnes	Col. 7 to Col. 3 %
1960-61	30.2	37·6	20.8	1.9	—	22.7	14.8	60.6
1965-66	35.4	43.3	27.74	4.3	—	32.4	11.8	73.8
1970-71	37.4	58.2	40.2	3.9	—	44.1	14.1	75.8
1980-81	51.4	59.1	49.7	0.6	1.6	50.3	8.8	85.1
1982-83	80.0	112.9	60.0	7.0	—	67.0	45.9	59.3

Source : Indian Sugar, New Delhi.

from the table that since 1969-70 the sugar prices are showing an unstable trend.

Major Constraints

Indian sugar economy has been facing a series of constraints which require a rethinking on all the facets of the same.

1. Production of sugar depends upon the quantity and quality of sugarcane available to sugar factories. Hence, the problem of supply of adequate quantity of high quality sugarcane at an economic price is of paramount significance. Indian sugar industry, particularly in Northern India is bound by two factors i.e. poor quality of sugarcane and its high price due to lower yield per hectare. The problem of low yield is the result of following old methods of cultivation, inadequate use of manures which are also not available freely and lack of sufficient irrigation facilities as well as disease-free seed. By and large, the requirment for enhancing cane productivity is quite well known and is the chief aim and objective of the Cane Development Programme. No less important is the need for evolving new varieties of sugarcane and for devising new scientific methods of cane cultivation.

reserved areas of the sugar factories. No new licences should be granted nor any change in the names of the licencee should be permitted nor further expansion of the existing khandsari units, power crushers operating in the reserved areas be allowed. Maximum price for gur and khandsari should be fixed and imposed right now to avoid competition for cane prices among these three sweeting agents. Added to this, the working hours of khandsari units, their date of start and also the quantity of sugarcane to be crushed may be fixed before the commencement of the season. All this needs to be done to avoid the diversion of cane to gur and khandsari units.

7. It is painful to write that in our country, there has been a relatively small and uneconomic size of sugar factories. No major breakthrough so far has been achieved in this direction. This problem must be given a top priority and all efforts have to be made for enlarging the capacity of these factories either by

Similarly, the developmental wings complaints regarding the lack of appreciation of practical probelms that makes the research findings of little value. More and more facilities as well as incentives must be given to this alarming problem. The scientists should be encouraged to undertake intensive as well as extensive research for the sound as well as rapid growth of this vital agrobased industry of the country.

Possible Solutions

1. A buffer stock can serve as a best method of keeping violent ups and downs to a minimum possible extent. For this, segregation of the buffer stock with the sugar mills is of paramount significance.

2. Effective implementation of maximum price for sugarcane by the Central Government.

3. Determination of the ideal size of buffer stock keeping in mind the export requirements, so that

reserved areas of the sugar factories. No new licences should be granted nor any change in the names of the licencee should be permitted nor further expansion of the existing khandsari units, power crushers operating in the reserved areas be allowed. Maximum price for gur and khandsari should be fixed and imposed right now to avoid competition for cane prices among these three sweeting agents. Added to this, the working hours of khandsari units, their date of start and also the quantity of sugarcane to be crushed may be fixed before the commencement of the season. All this needs to be done to avoid the diversion of cane to gur and khandsari units.

7. It is painful to write that in our country, there has been a relatively small and uneconomic size of sugar factories. No major breakthrough so far has been achieved in this direction. This problem must be given a top priority and all efforts have to be made for enhancing the capacity of these factories either by expansion on merging smaller units into larger units.

8. In our country many of the sugar factories are financially very weak. The plant and other appliances which were installed in thirties (1930) have become more obsolete and need immediate rehabilitation and modernisation. The Gundu Rao Committee has recommended the establishment of a revolving fund for the purpose. So far no much success has been achieved on this horizon. It is now become imperative that the public sector banks should come forward and open a collective window for overcoming this vital problem. As a matter of fact, it is a slow poison to the industry.

9. Lack of coordination between research and development has been serving as a fuel to fire. Recently, it has been noticed that the researcher finds himself helpless in transplanting his ideas into field practice due to nonavailability of facilities and needed resources. Similarly, the developmental wings complaints regarding the lack of appreciation of practical probelms that makes the research findings of little value. More and more facilities as well as incentives must be given to this alarming problem. The scientists should be encouraged to undertake intensive as well as extensive research for the sound as well as rapid growth of this vital agrobased industry of the country.

Possible Solutions

1. A buffer stock can serve as a best method of keeping violent ups and downs to a minimum possible extent. For this, segregation of the buffer stock with the sugar mills is of paramount significance.

2. Effective implementation of maximum price for sugarcane by the Central Government.

3. Determination of the ideal size of buffer stock keeping in mind the export requirements, so that international commitments could be met out effectively and properly.

4. Development of export markets for sugar on a regular basis.

5. Some sort of subsidy in regard to the export of sugar should be given.

6. To make the working of sugar factories viable for a longer period of time.

7. Well integrated policy keeping in mind all the facets of the industry.

8. Increasing role of public sector banks in solving the problem of modernisation.

9. Review of the existing licensing policy keeping in mind the prevention of set up of excess capacity in sugar industry.

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Rural Co-operative Financing Agencies

V. P. TRIPATHI
MADHU MATHUR

A cooperative society is not merely to supply finance, but also to supply confidence, courage, spirit of thrift and feeling of self-help to enfeebled peasantry. This paper attempts to give suggestions as to how to improve the functioning of rural cooperative financing agencies. Cooperative sector in our planned development has been greatly criticised but not sufficiently analysed.

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Inspite of Rural Credit Survey Committee's oft-repeated observation, 'cooperation has failed but it should succeed'; there has been too much assertion on 'cooperation has failed' and too little on 'it should succeed'. Since then the performance of cooperative sector in our planned development has been greatly criticised but not sufficiently analysed. Consequently the general public thinks cooperation to be an unfruitful exercise of the government, academicians an insignificant aspect of economic analysis and planners an idealistic liability. The academicians by and large treat its theoretical aspect with much reduced interest and planners feel that their duty comes to an end simply by allocating some resources for its development.[1] There has been developing a common tendency since the last two decades to ignore cooperation in every sphere and rural financing is not an exception.

Prior to Independence, there were only two agencies in the rural sector, private money lenders cum traders and cooperative credit societies. Cooperative Credit Socities came into existence precisely after 1905 as a result of Cooperative Credit Societies Act of the same year. This Act paved the way for the establishment of cooperative societies as a challenge to money lenders. After this there was a tremendous growth in the number and working capital

1. Tripathi, V.P. and Madhu Mathur : India's Planned Development and Cooperation, The Cooperator, Vol. XIX, No. 8 (1981).

of cooperative credit societies till Independence.[2]

However, these cooperative societies, could not bring about a substantial qualitative change in credit structure in Indian villages. These cooperative societies were put forth to provide the farmers with an alternative source of finance. But this hope could not be materialised. The Cooperative Societies could not become a formidable rival to the indigenous lenders in order to force them to liberalise their (indigenous lenders) terms and conditions of lending. The Rural Credit Survey Committee's Report brought this fact to light, when it revealed the exorbitantly high rates of interest charged in countrysides.

With growing use of mechanical devices, chemical inputs and consciousness among farmers to increase their marketable surplus, the need of finance grew more, leading to ever widening gap between credit needs of farmers and availability of it. Disappointed by this state of affairs the government decided to give entry to commercial banks to plug the gap between the two. But when this gap continued it decided to set-up another form of agency namely Regional Rural Banks, specifically for the said purpose. During this course of establishing, supplementing and complimenting the lending agencies, the state governments also offered their services as all other developmental work on their part were over and financing was the only problem to be dealt by them.

Here a careful examination of various efforts made by the government, shows that it made experiment after experiment in the field of rural financing. It introduced one agency after another without analysing the causes of ineffectivity of one and justification for installing the other. This is the reason why the state of rural financing has not been substantially improved and our farmers are still largely under the obligation of indigenous money lenders. The fact remains that money lenders still have a tight grip on rural farmers. According to an estimate, they supply near about 40 per cent credit needs of rural folks (See Table-1). Besides amount, more important thing is that money lenders have still higher percentage in total number of borrowers as they have obliged a large number of small and marginal farmers with petty amount of loans. Their percentage share will further swell if unregistered money lenders are also taken into account.

The policy of the government to install one lending agency after another has been irrational and unscientific. It has been just like sending one after another army battalions on front when the existing one is defeated without studying the strategy of the enemy causing its victory. In such a state of affairs all the additional battalion shall be crushed, no matter how many are sent in operation. Thus in order to win a battle, it is very important to know the power and capability of the rival. In other words, there is a need to study the reasons behind the popularity of money lenders. It should be thoroughly understood why these money lenders are popular despite their exploitative tendencies. Why is it that rural folks knock at their doors even though their terms and conditions are exorbitant ?

A close study reveals that the main reason behind the popularity of indigenous money lenders has been his close and organic link with rural folks. He is completely aware of the area and the persons therein. He has got personal contacts with the persons of his interest. His entire procedure of lending and recovery is sound and fool-proof. There are four stages in financing process viz. appraisal of loan requirement, process of disbursement, supervision of loan utilization and recovery of loan. Although not professionally qualified, a money lender has an excellent understanding and practical experience of all these stages.

The government just toys with the idea of aggressive lending but money lenders actually practice it. After having an accurate and precise idea of repayment capacity of prospective benefactor in his mind, he starts persuading him (the farmers) to accept the loan. For the purpose in question, he convinces the farmer about the benefits that he could accrue from his loan. He disburses the loan without any difficulty. The process of disbursement takes place quickly, conveniently, efficiently and without too many formalities.

At the time of recovery, a money lender is very cautious. He makes personal contact with the borrower and reminds him time to time regarding his dues without leaving any margin for unproductive spending.

2. Reserve Bank of India : Review of Cooperative Movement in India, From various statistical tables.

These observations make it clear that the money lenders possess some special qualities which make them popular in rural money market despite their exploiting attitude and exorbitant terms. These qualities are not possessed by rural financing institutions. Hence, there is a scramble of farmers seeking credit at the door of money lenders while credit institution face a problem of absorption and hence an idea of aggressive lending by institutions is often proposed and advocated. In fact, the popularity of credit is attributed to the terms as well as procedure of lending. But even the better terms cannot bear fruits in the absence of convenient procedure. It is not inappropriate to say that an efficient procedure is far more important than improved terms for our rural illiterate folk. This is the fundamental incantation behind the success of village money leaders despite their unfair terms and conditions.

The point is that a system which has close and organic link with rural society and can look at different odd rural farmers with a subjective outlook can only compete with money lenders and put a viable alternative to the farmers. These requirements cannot be fulfilled by the commercial banks or Regional Rural Banks. If these requirements can be met by any agency it would only be primary cooperative credit society, which has close links with farmers of its area and also has their own involvement in the lending process. Inspite of many lacunae and unfavourable infrastructure of Indian villages for cooperative organizations, cooperative societies have covered vast area and lent a commendable amount so far. In institutional financing it is the largest source of lending and constitutes nearly two third of total rural financing. The proportion of cooperative agencies vis-a-vis others in rural financing is shown in the following table which is self-explanatory.

The position of recovery of loans of cooperative agencies is also better than that of commercial banks. The present all India figure for recovery of cooperative agencies and commercial banks are 46 percent and 40 per cent respectively.[3] This substantial difference is because the cooperative organizations are democratic institutions belonging to the farmers. That is why, the management of the cooperative organizations has organic link with farmers and know them through and through. The commercial banks lack in this regard. This fact has been interestingly brought to the lime light by R.P. Noronha in this article 'Agricultural Financing'. Quoting him in extenso "The commercial banks are run by competent professional men, who could tell you all about International Monetary Fund and the World Bank and petro-dollar at the drop of a hat. But they do not know Budhram and Hiralal. They do not know that Lalaram had a bumper crop last year, still less are they related to Budhram and Lalaram and Hiralal. The management of cooperatives do when the Reserve Bank tears the strip off any Central Cooperative Bank, its manager does not issue a circular letter to the primary societies. He goes to his Chairman who is always a seasoned politician and always related to some Hiralals and Budhrams and the Chairman or one of the directors goes on a tour of defaulting areas and talks to Budhrams etc. pointing out that if there is not atleast some recovery, he (the Chairman) will get the order of the boot, and he (Budhram) will have to deal with someone less sympathetic. That is called personal touch in expensive books on management."[4]

Thus, the cooperative system has a greater potentiality to be successful on account of its qualitative superiority. Seeing the poor condition of rural masses, cooperative societies are the best suited agencies for rural lending. In our country there are a great number

Table 1

Agency	In percentage			
	1951-52	1961-62	June'71	1978-79
Institutional	7.1	18.7	30.2	60.0
(a) Government	3.3	2.6	6.8	3.3
(b) Commercial banks	0.9	0.6	2.3	16.7
(c) Cooperative organisations	3.1	15.5	21.2	40.0
Non-Institutional	92.7	81.3	69.8	40.0

Source : Kurukshetra, No. XXVIII, No. 18 (1980).

3. Noronha, R.P. : Agricultural Financing, Man and Development, Vol. IV, No. 1 (1982), p. 175.

4. Ibid., p. 180.

of small and marginal farmers who hardly have anything for security purpose against their loans. These farmers find it difficult to arrange sureties also, as most of the rural well-to-do (who can stand as sureties) do their own business of lending. In such a state of affairs only cooperative credit system can help, where man and not money counts and loans can be sanctioned on the basis of personal security. In such a system, the amount of loan granted to the borrower can be assessed on the basis of a number of factors other than project cost and value of security. In commercial banking system, these other factors are largely ignored, for example, the subjective factors regarding the living conditions, liabilities, character and background of the borrowers are not given importance. This is why in the cooperative credit system even the small and marginal farmers with meagre resources are able to fetch. This is evident from the figures that in the case of cooperative credit 40 percent of production credit and 50 percent of investment credit has gone to the weaker section.[5] There is no better yardstick to measure performance of cooperative than this.

Even if a rural illiterate farmer has got something as security, it is difficult for him to get loan sanctioned quickly as it is not easy for a farmer to get 'No Due' certificate from irrigation, revenue etc. departments. Such declaration is not difficult to get not only by the illiterate farmers, but even bank officials have been reported to have been making complaints that they do not get cooperation from different revenue departments. This is one of the most important impediment regarding quick disposal of loan application.[6] Thus loans are delayed and either become useless or less useful. On account of such delays a farmer has to pay an invisible additional price which off-sets his advantage of lower interest rate of commercial banks, and commercial bank's rate of interest comes at par or higher in actual terms. This fact does not need much assertion that even a little delay in agricultural process may incur substantial loss to the farmers. On the other hand such delays are avoided in the cooperative system. A farmer seeking loan has links with members of management and on account of his continuous persuasion he is able to get his loan sanctioned.

The large-scale favouritism is often referred in cooperative system, but that is confined to favouritism only, which is in a number of cases not undue also. That may be a 'positive kind of favouritism', while with commercial banking system, this is not just favouritism but high degree of corruption and misappropriation of funds. In the absence of personal contact with branch manager and a long chain of formalities creates a haven for touts and intermediaries, who charge an additional price to get loan delivered at the door of the applicant. A regional level survey conducted by Prof. Mahesh Chand and Prof. B. Singh of Allahabad University confirms author's view.[7] Again in such a case the advantage of lower rate of interest, which he could have by seeking loan from institutions instead of money lenders may disappear. In cooperative system such possibilities are mitigated if not eliminated completely.

Apart from its visible advantages cooperative system helps farmers to enhance their invisible qualities. The pioneer of cooperative movement in India, Fredrich Nicholson, rightly holds that a cooperative society is not merely to supply finance, but also to supply confidenc, courage, spirit of thrift and feeling of self-help to enfeebled peasantry. According to him a cooperative society provides an education in many finer, social and economical facets. These are not merely to popularise, but democratise credit.[8]

The stated observation of Nicholson suggests that one should not assess the success of cooperative movement in monetary or physical terms, but more important is, its invisible contribution to the society. In the case of cooperative organizations we should think in

5. Desai, S.S.M. : Rural Financing in India, p. 154.
6. Chaubey, P.K. and V.P. Tripathi : Howmuch Cooperative Land Development Bank in U.P. ? Uttar Pradesh Arthik Patrika, P. Vol. II, No. 3 (1981).
7. A recent study at regional level conducted by Prof. Mahesh Chand and Shri B. Singh at University of Allahabad, captioned as "Evaluation of the working of the Lead Bank Scheme for Development of Agriculture in Bharatpur Distt. of Rajasthan" Unpublished,
8. Quoted by Shri P.K. Chaubey and V.P. Tripathi in their article captioned as "Adequate Cooperative Orientation of LDBs in U.P." published in NCDC Bulletin, Vol. XIX, No. 6 (1981).

terms of social profitability not merely in terms of material profitability. Unfortunately the tendency of counting on material profitability is on the increase. Lamenting on such a state of affairs, Dr. R.C. Dwivedy opines "over emphasis on commercial aspect of cooperatives, measuring their efficiency with the yardstick of volume of profits, ignoring the social content of their business operations and obligation to execute government's policy, is another visible trend which is a matter of anxiety and concern."[9]

In the last eighty years cooperatives have endeavoured to open their business in the far-flung hilly and remotest areas and introduced people of institutional credit which they had never heard of, thus, making it easy for coming institutions to hold ground. The commercial banks or Regional Rural Banks of which ever came in the later stage, shall always be indebted to their forerunner single agency i.e. primary cooperative credit society.

So far, we have discussed cooperative societies/bank vis-a-vis commercial banks and we have concluded that cooperative credit system has its own merits and cannot be substituted by commercial banks. The same thing remains true with recently opened Regional Rural Banks. Though it would be too early to make any definite comment on their performance, but one thing is clear, that there is hardly any functional difference between the branch of commercial banks and Regional Rural Banks. The limited area, small changes in lending policy and reconstituted board of directors hardly differentiate them from commercial banks. The quality of being a democratic institution of farmers and its local orientation can never be brought about in these banks. In fact, they are very much akin to the commercial banks. Then what purpose does the different name, banner and band-wagon serve, if it is not a fiasco to fool the innocent peasantry.[10]

Thus, our efforts should be made to the reform cooperative system itself. The most important step towards the success of cooperative credit system is to provide it with adequate guidance, supervision, help and efficient control by the Reserve Bank of India. It is truly observed that it is Reserve Bank of India that has failed and not cooperative system in controlling and regulating credit. But a monolithic giant like Reserve Bank of India cannot do it to efficiently. Hence recently created National Bank of Agricultural and Rural Development should be entrusted this responsibility entirely. We hope it will be a right step towards improving the present state of affairs.

There should also be a thorough overhauling of cooperative infra-structure. One can easily identify its lacunae which are e. g. influence of rural demogogues and big-wigs; inefficient, poorly trained and low-paid staff, lapses in procedure of working etc. It would be too much to think of eliminating the 'rural bosses' from the picture. Anyhow they would manage to corner a good chunk of rural finance to serve their purpose. This possibility cannot be ruled out in any system. Experience tells us that they enjoy this 'privilege' in commercial banking systems also. But the problems regarding efficient working and improvement of the infrastructure, may well be solved by adopting some aspects of the working procedure of commercial banks. The cooperative banks should also attain quick and efficient procedure so that deposits and withdrawals are made quickly, which is the biggest plus point of commercial banks. This thing largely depends on bank staff. Some efficient personnel should be invited from commercial banks not only at management level but at clerical level also. This can be an important step towards raising efficiency of cooperative banks. But the practice of deputation should be shunned at state level management, where chairman, managing directors and other directors are frequently appointed or deputed from amongst I.A.S. bureaucratic officers, who work merely with commercial motives and hence deface true cooperative spirit and stature of cooperative organizations.

In addition to improving procedure of working of the cooperative organizations efforts should be made to bring down the rate of interest. The rate of interest can be lowered down, if serious efforts are made in this direction. Under the present three tier system (state, central and primary level societies) the rate of interest becomes quite high. In the typical case of

9. Dwivedi, R.C. : Approach to Cooperative Movement in India, Indian Express, March 9, 1979.

10. Cf., Wadhwa, Charan, D.: Rural Banks for Rural Development, pp. 11-13.

Uttar Pradesh the interest rate has nearly doubled during canalization of loan from state to central cooperative bank to primary society to borrowers. The Uttar Pradesh Rajya Sahkari Bank Ltd. borrows from Reserve Bank at the rate of 6.25 percent, then UPRSB gives to District Cooperative Banks at the rate of 7.50 percent. These DCBs then give to PCCSs at the rate of 9.75 percent and then finally cooperative societies at the rate of 12.25 percent. It is clear that on account of these intermediaries the rate of interest is sizeably enhanced. It is also to be pointed out, that loans are given directly to public by UPRSB and DCBs for production purpose. The UPRSB has lent huge sums to sugar mills and other industries. Thus giving the advantage to cooperative credit to industrialists rather to small farmers. Having direct dealing with RBI its profit margin is also very high. Hence it is earning sizeable profit every year. Any one can see the steep rising curve of profit behind the M. D.'s chair, in the ten storied ostantatous building of Uttar Pradesh Rajya Sahakari Bank Ltd. It is surprising that despite of showing high rising curves and making tall claims of their success, no efforts are made to improve infrastructure of PCCS or reduce their rate of interest. It seems that every Managing Director who is by practice some top class beareucrat of the government who is anyhow interested in showing the best performance under his nose only, thus leaving poor PCCSs on their own fate.

It may, therefore, be suggested that the effective dominance of bureaucrats on the Board of Management should be taken-off. It should be seen that such key positions are held only by those who are really devoted to cooperative movement and think in those terms rather showing their own performance in terms of profit earned. There must be serious efforts to cut-short the long canalization through the three aforesaid stages. The whole cooperative credit edifice should work under the regulations of NABARD, and state and district level cooperative banks should work just as regional and district offices for the purpose of coordination, checking and looking after such things. The PCCSs should have full rights to apprise and dispose off loan applications and all the matters regarding advancing loan should be settled just at its level. At present the district cooperative banks are much involved in advancing loans through PCCSs, which makes the farmer to shunt between DCB and PCCS.

Finally, it may be restressed that the government should allow the cooperative system itself to take lead in rural lending and put its energy to improving it rather than replacing it. Cooperation in general and cooperative credit system in particular aims at broader objectives, and it may, therefore, take much time in giving excellent results, but one thing is sure that it would give excellent results in long-run. In a democratic system, democracy gives people an opportunity to improve themselves, and then people improve the democratic system. In this way, this process of chain reaction takes much time to develop into a state of real democracy. But it does not mean that we should desperately overthrow the democratic system. There are general complaints with the democratic institutions like Panchayat Raj, local bodies etc. and cooperation is also one of them. We should not forget that in the process of continous interaction with such institutions, people learn a lot. It would not be wrong to say that these institutions have been responsible to a great extent for political awakening and consciousness. Those who are disappointed with such institutions and ridicule them, have they ever realised that in the absence of these what would be the source of teaching lessons in democracy and ensuring peoples' participation in developmental planning in a vast country like ours, where many states are equal to the size of many countries. In concluding remarks, we can once again hail the observation of Rural Credit Survey Committee's oftrepeated observation 'cooperation has failed but it should succeed' and ofcourse our greater assertion is 'it should succeed'.

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Analogue Models for Location Problems

D. K. BANWET
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This paper presents some analogue models developed by the authors for optimal location in single facility Weber's location problem with and without constraints due to forbidden zones. Iso-cost curves using the models have been shown and the accuracy of alternative analogue models have been compared. The analogue models proposed are simple, easy to make and quickly give the near optimal solutions.

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Introduction

Facility Location Problems (FLP) are strategic in nature. The complexity of the problems could range from placing components on an electronic circuit board, to locating canteen, office, spares stores within a factory to that of locating factories, hospitals, firestations, police stations, community centers, post offices, godowns, warehouses, storage centers, depots etc. Location problems, though seemingly diverse, have basically a common underlying structure.

The locational decision is to locate a new/main facility (facilities) having some interaction with a set of existing ancilliary facilities so as to optimize some appropriate criteria of effectiveness, such as transportation costs/material handling effort etc. There have been a variety of formulations treated analytically for essentially unconstrained form of FLP as can be seen in reviews by Cooper[3], Lea[10], Scott[11], Francis and White[6] among others. The focus of this paper is to develop analogue models to solve apart from unconstrained FLP the more realistic case of the constrained form of Weber's location problem.

Unconstrained Weber Problem (UWP)

The single source unconstrained planar Weber[12] location problem can be mathematically stated as follows :

Given a set of n ancilliary facilities, A_i, $V_i=1, \ldots n$

(a_1, b_1) are the co-ordinates of the fixed location of the ith ancilliary facility

(x, y) are the co-ordinates of the proposed location of the single main facility

w_i the interaction between the ith ancilliary facility and the main facility. (It is a measure of the handling efforts and usually represents transportation costs per unit distance).

d_i the Euclidean (shortest/straight line) distance between the location of the ith ancilliary facility and the proposed location of main facility.

viz. $d_i = ((x-a_i)^2 + (y-b_i)^2)^{\frac{1}{2}}$

$F(x, y)$ the total cost function which is the sum of the costs of transporting/handling between the main and the ancilliary facilities.

The problem is to determine the point P (x,y) such that the total cost

$$\text{Pl: } F(P) = F(x, y) = \sum_{i=1}^{n} (w_i d_i) \text{ is a minimum}$$

On substituting the expression for d_i and setting partial derivatives $\frac{\partial F}{\partial x}$ and $\frac{\partial F}{\partial y}$ to zero results in

$$\frac{\partial F}{\partial y} = \sum_{i=1}^{n} \frac{w_i (x-a_i)}{((x-a_i)^2 + (y-b_i)^2)^{1/2}} = 0 \quad \ldots(1)$$

$$\frac{\partial F}{\partial y} = \sum_{i=1}^{n} \frac{w_i (y-b_i)}{((x-a_i)^2 + (y-b_i)^2)^{1/2}} = 0 \quad \ldots(2)$$

Equations (1) and (2) cannot be solved easily for getting the optimal values of x and y. Some numerical iterative techniques have been proposed by Kuhn and Kuenne[9], Cooper[3], Francis and White[6]. The problem PI has been treated extensively both from the theoretical point of view[2,3,4] and from the point of view of applications[3,6,9]. The present paper's approach is in deriving good solutions to PI with the aid of analogue techniques. Various analogue models developed to solve the Weberian Location Problem were (i) Mechanical Analogue (ii) Electro-mechanical Analogue (iii) Electrical Analogue and (iv) String Analogue.

Analogy

In the mechanical analogue[6], the equilibrium of coplanar forces is analogous to the optimal location. Each ancilliary facility attracts the main facility towards itself. The force of attraction is proportional to the respective weights or interaction between the existing ancilliary facility and the proposed new facility. The various pulls on the proposed facility soon settle for a consensus equilibrium which results in the desired optimal location.

As for the electrical analogue, distance (d_i) and weight (w_i) are similar to the length of resistor (l_i) and resistance per unit length (r_i) respectively. The product of distance and weight viz. the total transportation cost is therefore analogous to the total resistance (R).

$$R = \sum_{i=1}^{n} (r_i \times l_i)$$

As per ohms law R= (Voltage (V)/Current (I). Minimizing total transportation costs therefore amounts determining the point which registers the minimum total resistance or maximum current in an appropriate series electric circuit (which is shown in figure 2), rather than the meter bridge circuit used by Hitchings[7].

The electro-mechanical analogue uses the above two analogies simultaneously. Results of the mechanical analogue help in readily searching in and around the optimal zone by the electrical counterpart. Also iso-cost curves can be charted easily.

String analogue models are based on a concept somewhat similar to the string Diagram in work study. The length of the string traversed is twice the value of the total transportation costs. As the model and results therein (application to constrained Weber facility location problem) have already been reported[1] hereafter most of the discussion will focus on the mechanical, electrical and electro-mechanical analogue models essentially.

Analogue Models For Solving UWP

The set-up of the three analogue models is shown in figure—1. A square grid of one unit was drawn on a sheet of paper which was placed on the face of the iron-base structure. Ancilliary facility locations were fixed up by method—1 (figure 1 : (a), (b) and (c) in case of the mechanical and electro-mechanical analogues and by method-2 (figure 1 : (a); (b) and (d) in ease of the electrical analogue. The wires connec ting cach ancilliary facility were connected to a central plug (figure—1 (b). In the case of the mechanical analogue the plus connections do not require much attention. However for the electro-mechanical and elec trical analogue model, the connections necessitate the formation of a series circuit and precautions against any short circuits. The electrical circuit for the two analogue models is a simple series circuit. For even number of ancilliary facilities, the circuit would be of the type shown in figure 2 (a) whereas for the odd number of ancilliary facilities the circuit would be of the type

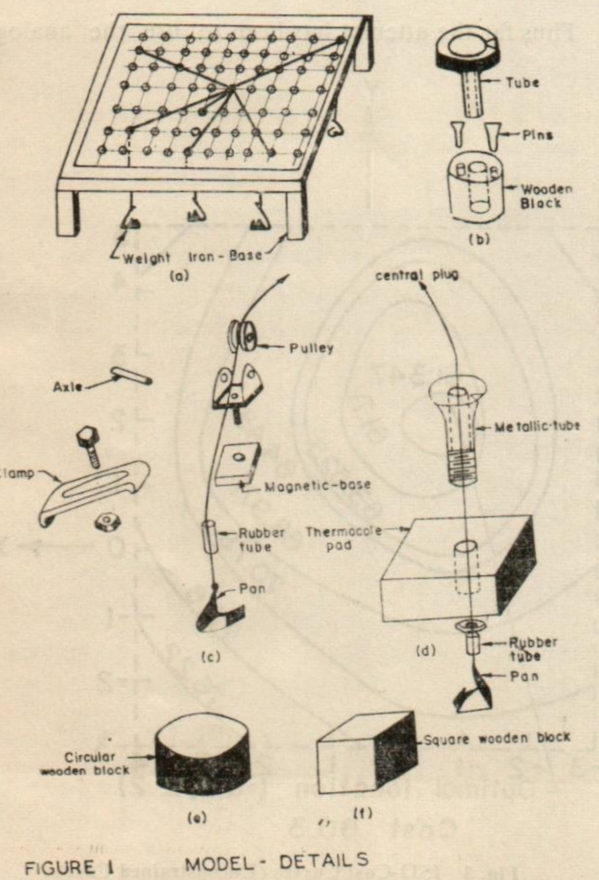
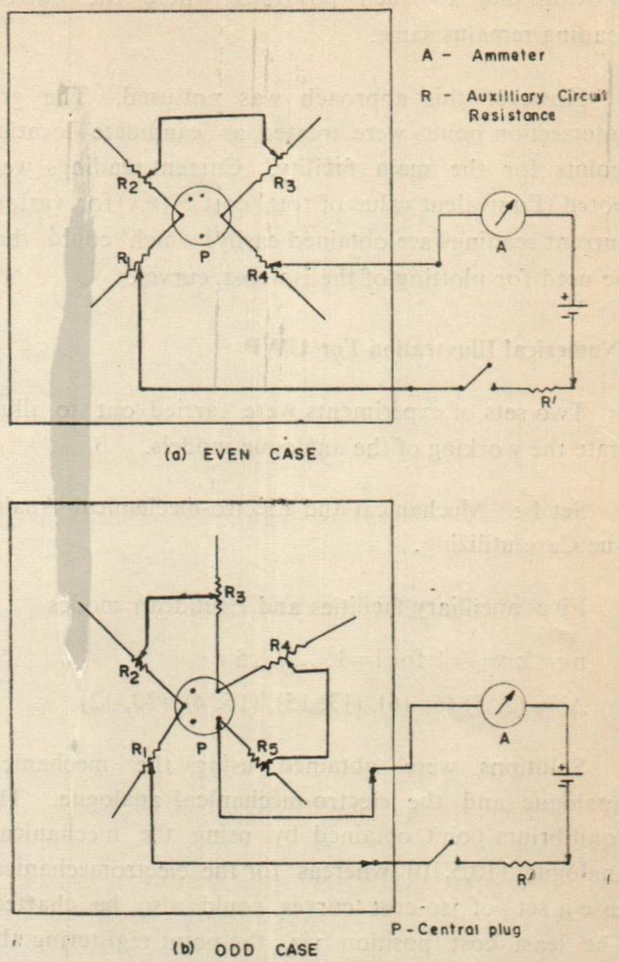


FIGURE 1 MODEL - DETAILS



R_1, R_2, R_3, R_4, R_5 Analogous to Ancilliary facility Locations I, II, III, IV & V respectively.

Fig. 2 Electric Circuit-Diagram for Model

shown in figure 2 (b). Actual weights (w_i) need to be placed on the pans for getting the mechanical analogue solution. This is however not necessary in the other two analogue models. Only some weights are necessary to keep the resistor connecting wires taut so as to maintain the necessary contact to complete the electric circuit. The choice of wires, their configuration (viz. cross-sectional area, resistance per unit length etc.) needs to be done judiciously so as to truly reflect the actual problem on hand.

To get the optimal location, the plug can be moved around till the time when the maximum current (or minimum resistance) is registered in the circuit. Iso-cost curves can also be plotted simultaneously by moving plug to such positions where the current reading remains same.

However this approach was not used. The grid intersection points were treated as candidate location points for the main facility. Current readings were noted (Equivalent value of total cost F (x,y) for various current readings are obtained easily) which could then be used for plotting of the iso-cost curves.

Numerical Illustration For UWP

Two sets of experiments were carried out to illustrate the working of the analogue models.

Set 1 : Mechanical and Electro-mechanical Analogue Case utilizing.

Five ancilliary facilities and Euclidean modes

$n = 5$; $w_i = 1$ for $i = 1, \ldots\ldots, 5$

$A_i = (2, 5)\ (6, 16), (13, 15), (15, 4), (20, 12)$

Solutions were obtained using the mechanical analogue and the electro-mechanical analogue. The equilibrium point obtained by using the mechanical-analogue (10.5,10) whereas for the electromechanical case a set of iso-cost curves could also be charted. The least cost position viz. the point registering the maximum current was the optimal location which was (11.6, 11.8). Both results were compared with the iterative numerical solution of (11.97, 11.92) as can be seen in the table follows.

Sl. No.	Method	Best Solution Co-ordinates obtained		% Error as Compared to Numerical Solution	
		X*	Y*	X*	Y*
1.	Numerical (Iterative)	11.97	11.92	—	—
2.	Mechanical Analogue	10.5	10.0	12%	16%
3.	Electro-Mechanical Analogue	11.6	11.8	3%	1%

Results of electro-mechanical analogue were better. The mechanical analogue suffered because of mechanical friction loss at pulleys, variation in weight of the pans and weight of the central peg/plug. As for the electro-mechanical case, there were variations in the voltage supply and poor contact at pulleys resulting often in discontinuity of the series electrical circuit. A much improved version for the electrical analogue was devised utilizing the set up of figure 1 (a), (b) and (d). The second set of experiments were carried out using these modifications.

Set 2 : Electrical Analogue Case—

Four Ancilliary Facilities and Euclidean Modes

$n=4$; $A_i = (a_i, b_i) = (-3, 6), (3, -4), 5, 6), (4, -3)$

$W = w_i \quad = 2.21, \quad 1, 1.26, \quad 1.26$

The results are illustrated in figure 3. Iso-cost curves are useful to the location decision maker in case the facility is restrained from being located at specific points or regions.

Constrained Weber Problems (CWP)

Thus far the attempt has been to use the analogue

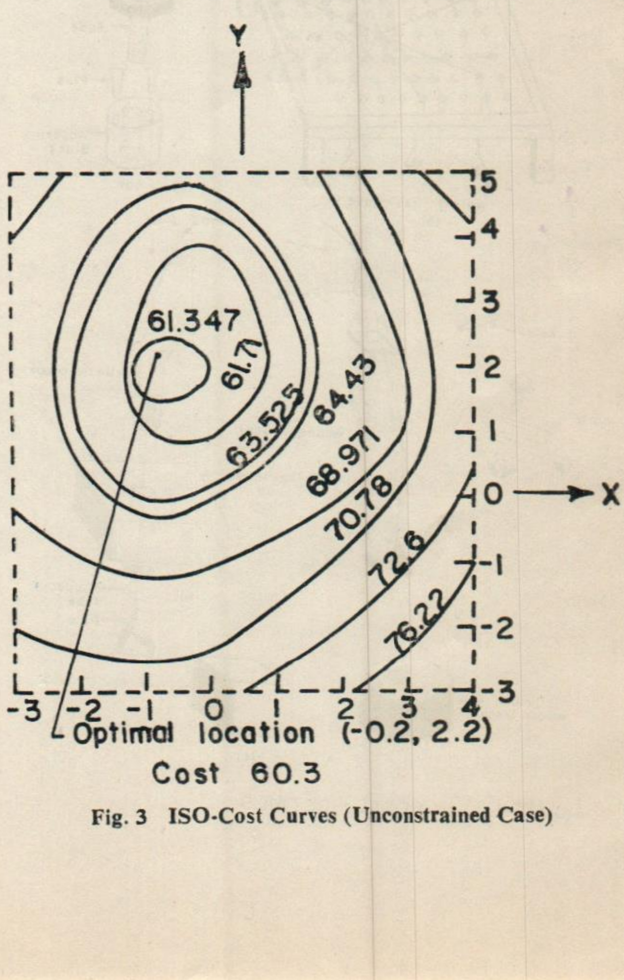


Fig. 3 ISO-Cost Curves (Unconstrained Case)

models for solving the unconstrained form of Weber's location problem Pl. In a more practical case however it could happen that neither the main facility can be located in some forbidden regions FR (Figure 4) nor is any travel between the main and ancilliary facilities permitted through these forbidden areas. Restrictions may occur because of safety, anti-pollution measures, town planning ethics, legal, socio-economic or geographical factors. The location region may be infested with lakes, marshy lands, park areas, mountains or defense installations.

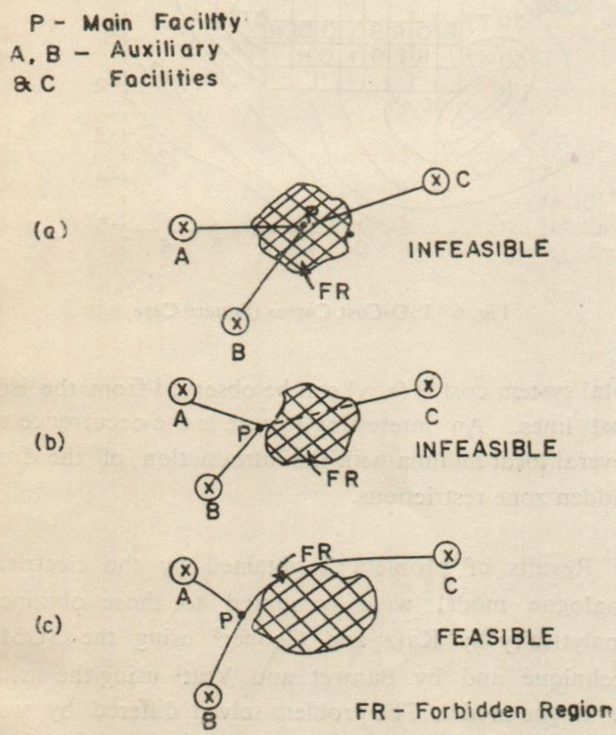


Fig. 4 Location Solutions

The constrained single source Weber's location problem formulation is to determine the point P (x, y) $\in$FR, such that the total cost

$$P\,2: F(P) = F(x, y) = \sum_{i=1}^{n} W_i\, d_i^* \text{ is a minimum.}$$

$$P \in FR$$

Here d^*_i is the shortest path between the main facility and ith ancilliary facility which does not intersect or cross any forbidden region. $d_i^* = d_i$ in case no obstruction comes between the straight line joining the main facility location and ith ancilliary facility location. If a wire is held tightly between two points, the length of the wire between the two points will be the shortest (Euclidean) distance. Any obstruction placed between the two points results in the wire assuming a geodesic form in which case $d_i^* \neq d_i$. Strictly speaking $d_i \geqslant *_i$. Difficulty often arises in determining which of the two geodesic paths between a pair of points gives minimal d_i^*. A guideline for the single circular forbidden case was established by Banwet and Vrat.[1] A similar guideline can be derived for the rectangular and square forbidden cases.

Katz and Cooper[8] have used the SUMT (Sequential Unconstrained Minimization Technique) approach of Fiacco and McCormick[5] to solve problem P2 for single main facility single circular forbidden region case. Benwet and Vrat[1] have devised the string Analogue model for solving CWP. The analogue models are exceedingly simple and versatile enough to handle various types of geometrical configurations of forbidden zones.

Analogue Model for Solving CWP

In this paper the electrical analogue model has been used to derive answers for CWP. As observed earlier on the distance, d_i, is analogous to the length of the resistor, l_i. In the geodesic case d_i^* is similar to l_i^*. Therefore minimizing total transportation costs amounts to determining the point which registers minimum total resistance (Now $R = \sum_{i=1}^{n} (r_i \times l_i^*)$ or maximum current in the appropriate series electric circuit.

The experimental set up of the electrical analogue is used again. In addition to this, the forbidden region configuration, constructed from wooden blocks, are fixed at the locations where such restrictions exist. Once again the grid intersection points are the candidate location points for the new facility for which the resistance/current readings are noted. It is however important to follow the established guideline for choosing the right geodesic path so as to arrive at good and reliable results.

Numerical Illustration for CWP

Two problems were solved to illustrate the working of the analogue model for the constrained form of Weber's single facility location problem.

Problem 1: Five ancilliary facilities and one square forbidden region.

$n = 5, w_i = 1$ for $i = 1, ..., 5$

$A_i = (-1, -5), (7, -1), (-8, -6), (4, 10), (-7, 13)$

Forbidden Region Configuration is a square of sides 4 units each. The centre of the square is located at (0, 0) and its sides being parallel to the x and y axes.

Problem 2: Five ancilliary facilities and One Circular forbidden region.

$n = 5, w_i = 1$ for $i = 1, ..., 5$

$A_i = (-1, -5), (7, -1), (-8, -6), 4, 10), (-7, 13)$

Forbidden Region Configuration is a circle of radius 2 units, The centre of the circle is located at (0, 0).

The results of problem 1 are given in figure 6 whilst those of problem 2 are given in figure 5. Optimal location points are indicated whilst the sensitivity of the total system cost F (x, y) can be observed from the iso-cost lines. An interesting feature is the occurrence of several local minima with the introduction of the forbidden zone restrictions.

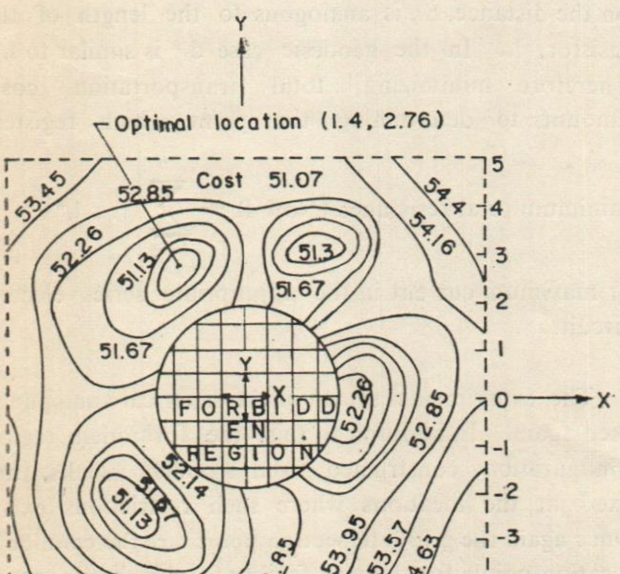


Fig. 5 ISO-Cost Curves (Circular Case)

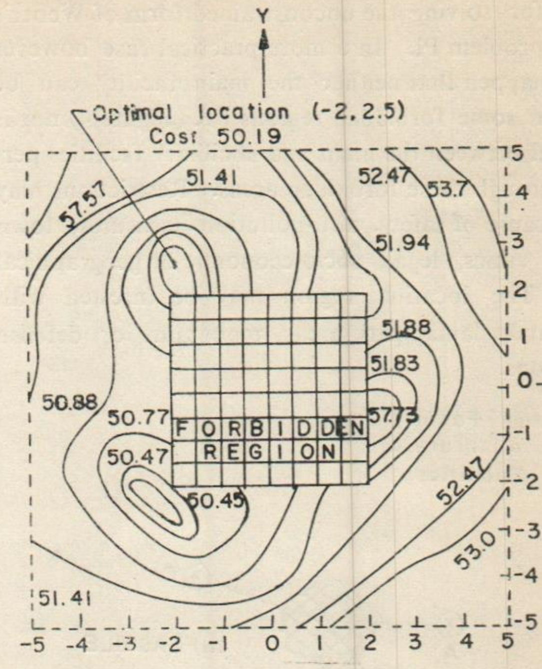


Fig. 6 ISO-Cost Curves (Square Case)

Results of problem 2 obtained by the electrical analogue model were compared to those obtained analytically by Katz and Cooper[8] using the SUMT technique and by Banwet and Vrat[1] using the string Analogue model. The problem solved differed by way of two ancilliary co-ordinate location points viz. (6.6, −0.5) and (4.4,10) were replaced by (7, −1) and (4,10) respectively because holes made in the iron base plate could only accomodate integral values. Yet the values of optimal location and total system cost F (x, y) were comparable as can be seen below.

The electrical analogue model, with a slight edge over the string analogue model, that has been developed and tested is a simple, reliable and versatile tool to solve the unconstrained as well as the constrained form of Weber's facility location problem. An advantage over the SUMT approach is the ease with which the experiments can be carried out for a variety of forbidden region configurations and formulations.

Technique	Optimal Location (x, y)	Optimal Total System Cost F (x, y)
Katz and Cooper (SUMT approach)	(−1.145, 2.620)	48.381
Banwet and Vrat (String Analogue Model Approach)	(−1.5,2.000)	49.750
Electrical Analogue Model	(−1.4, 2.760)	51.070

A high level of accuracy is achievable by the analogue model. Wires connecting central plug and weight pans should preferably have a uniform resistance per unit length so as to cater to linear transportation costs. Also a high resistivity of the wires would ensure larger deflection in current readings even for minor variations in length d_i. Eureka wire has been used in the models. The model can also be suitably adapted for non-linear transportation cost case by appropriately segmenting the wires for varying cross-sectional areas. This has not been attempted as yet. Wire breakages can possibly occur while experimenting for the forbidden region cases. However careful handling and a proper selection of wire diameter would prove very beneficial. The model should be operated with a DC supply that remains constant with negligible fluctuations and also the voltage should not be that high to result in excessive heating of the wires. Most of the above mentioned factors can be taken care of easily to make the above developed analogue model a very useful tool for solving Weber's FLP.

Conclusions

The analogue model has been illustrated for the single circular and square forbidden region case. This can be easily extended for a greater variety of forbidden region configurations. Research is currently in progress to make the analogue model workable for the multi-source Weber problem (initially in its unconstrained form). Realistic constrained facility location problems both single and multiple source are challenging and it is claimed that the analogue models (both electrical and string) developed here will be of immense use to location analysts to make good, reliable and quick decisions as compared to otherwise complex computationally difficult analytical/computerised procedures.

Acknowledgement

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Productivity
1985, XXV, 4, 4 75-479

Quality—Productivity Interface

M. V. V. RAMAN

In this article, the author discusses with various examples the relationship between quality and productivity. Productivity and quality have a major role to play in the economic development of the country. It is necessary for every nation to evolve its own quality strategy appropriate to its local conditions.

M V V Raman is Regional Director, National Productivity Council, Bangalore.

At Macro Level

In this article the meaning of Quality and Productivity would be used as applicable in the real world situations. Quality would be understood as being described by a set of specifications for a given use. Productivity would be defined in the context of decent standard of living of the people at large, and continuously improve the same by providing goods and services required by the community at prices which it can afford. It is only in the context of availability of goods and services for the common man, for his comfort and convenience, the interrelationship between quality and productivity has to be appreciated. All other situations would not be of any relevance to the present discussion.

Increasing productivity (productivity defined as ratio of output to input) need not improve quality; it may reduce the quality, though it is not a necessity. Improving quality may or may not improve productivity and even if it improves, it is indirect in most cases. Quality aspects in goods and services provide satisfaction to people at large, and productivity makes it feasible. In this sense productivity and quality go together. Coming specifically to the objectives of organisations it is only through the manufacture of desired quality, supported by productivity that stability and growth could be achieved and not the otherway.

Productivity is generally understood to mean the effective utilisation of resources, and is defined as the rate of output to input; it is presumed for a defined quality as well. Whenever there is a ratio, it is easy to visualise the number of ways in which productivity can be increased in any given situation. However, increase in productivity, in terms of output, costs, quality and convenience, can be achieved on a substantial basis through technology; for example one has to scan the improvement that have taken place over the century in various fields, from ox cart to supersonic transport, newer drugs, communications etc.

Productivity and quality have a major role to play in the economic development of a country. This is not merely for the sake of effective utilisation of scarce resources, but also for exporting products and services of Indian origin. Quality, in terms of customers requirements has to be met and at the same time has to be competitive. In this sense quality and productivity are directly related to effective management, technology and keeping abreast of competition.

Productivity improvements occur when the output is increased for the same input; the same output is achieved for decreased inputs, or any changes that makes the ratio of output to input higher compared to earlier situation. Another useful way of looking at this is from the point of view of reduction in cost per unit output.

An appropriate quality strategy will lead to cost reduction, while satisfying the consumer requirements; it will have in it elements of effective utilisation of all input resources, avoiding wastes in all forms, of men, machines, materials and other inputs, increasing the value of output by quality improvements, including output increases. Naturally this would improve the output-input ratio on a continuous basis.

The above are the broad areas of interrelationship between quality and productivity. However when one enters into the area of tools and techniques of "qvality" in a given set up, there are more specific issues that bring out the relationships clearly. It would become necessary to dwell briefly some of them to high-light the same.

At Micro Level

Three distinct meanings (certainly not independent of each other) may be given to "quality" to enable one to appreciate the meaning and implications of quality in a wider perspective and also enable one to design an appropriate quality control system keeping in view the implications of these distinctions; they are quality of design, quality of conformance, and quality of performance. Theoretically the two aspects namely, quality of design and quality of conformance lead to the manufacture of the finished products. Quality considerations do not end here; as experience has shown, customer satisfaction is the ultimate objective and is therefore necessary to see how the manufactured products fare in the hands of the customers and hence the third distinction of quality, viz., quality of performance while it is in actual use assumes significance. Quality of performance is concerned with satisfactory performance of the product in the field in the intended way and providing customer satisfaction.

When once the design quality is specified, the whole production process will be adjusted to manufacture to the specifications. Here starts the problem of "conformance", viz., producing items to conform to the established specifications. The problem arises from the fact that every manufaeturing process exhibits variability. This aspect is well recognised, for in the manufacture of any product, a certain amount of tolerance is always specified.

If variation is inevitable in any manufacture, the question arises how much of this variation should be allowed to be consistent with the requirements and how to determine this allowable variation ? The answers to these questions lead to the meaning of control.

The concept of control implies the study of quality characteristics through which a process is judged for conformance or acceptability. This is obtained by determining a model for the process behaviour, when the external causes affecting the process have been eliminated. Experience has shown that whatever be the quality characteristic under study, when the process is influenced by chance causes alone, it always takes the same pattern which is taken as the model for a satisfactory process behaviour. The properties of the model then become the characteristics of a process in a state of control. Essentially, since the model is known a controlled process is a perdictable one, i.e., the limits within which the values of characteristics under consideration are expected to lie are known, provided the state of control is maintained.

The concept of control is discussed above can be made use of effectively under the following three steps :

(i) Evaluation of existing standards
(ii) Maintenance of standards
(iii) Improvements upon standards

Briefly, evaluation of existing standards involves studying a given process for ascertaining the status as to its control, at the right levels of the parameters and to harmonise the design requirements with the manufacturing abilities of the process; when once this is achieved the problem of maintaining the control becomes important and control procedures assume significance. In case harmonisation of design requirements and the manufacturing ability has not been achieved, as revealed by the initial study, the problem has to be further investigated, including experimentation, to achieve harmonisation or take appropriate managerial actions. Improving upon the standards means taking advantage of the knowledge gained in the process of exercising control to achieve economics in the maintenance of control over the processes.

The quality control approach to problems may be presented, emphasising some principles, of which two are most important. The first may be called the principle of coordination, and the second the principle of prevention.

Coordination, in the wider sense, has already been mentioned, while discussing about "quality". It has been pointed out that the meaning of quality pervades all spheres of activity in an organisation, and thus it is absolutely necessary to conceive of the quality control function as coordinating the quality activities in the various departments, including customers' requirements and reactions.

Another important aspect of coordination is within the production cycle of a product. Here the coordination based on SQC concepts have brought immense benefit. This aspect may be explained in the following terms: In any production cycle, there are major functions—design, manufacture, and inspection. These three functions were treated as almost independent, until researches into the model for process behaviour, and through it the knowledge of capability of processes, came to light. For instance, specifying tolerance has an implied cost aspect in it. For any given output, the cost of manufacturing increases as permissible tolerance is restricted. If tolerances are set tightly, meeting the specifications with effective control increases cost of operations; and if they are not met, the cost of rejections would increase. It is thus essential to recognise an economic balance in setting tolerances. This approach requires, apart from functional aspects, a knowledge of the variations operating on the processes and techniques for analysing them, which cannot be provided by the routine inspection functions.

The second principle is the principle of prevention. The important aspect to consider in any actual manufacture is the elimination of the causes of defects as manufacturing is continuing. The routine inspection procedures attempt to sort out the items produced as good or bad. This approach can be replaced by a new one—of taking corrective action as and when manufacturing is continuing based on the model for process behaviour.

Summarising the quality control approach, the important ideas to be noted are :

(i) The idea of building quality into the product rather than inspecting it
(ii) Feed-back of information which assists in coordinating the activities of the various departments
(iii) The use of data in studying cause-effect relationships
(iv) Which lead to taking action on the process
(v) Importance of planned collection and effective use of data, including experimentation.

Examples

Four examples are described briefly to show the quality-productivity relationship at the micro level. They relate to benefits of control exercise over process, economies that can result through understanding process capability concept, reducing rejections (problem cases) and interpretation of specifications for effecting economies.

(i) The first example relates to the control over the diameter of the pedal axle. Originally the usual inspection methods were being applied to control the process to its specifications, namely 0.560" ± 0.002". The process was examined from the quality control approach with the aid of a control chart. The first study report pointed out (the control charts are not shown).

(i) The process is not in a state of control.

(ii) The process has gone out of control on both sides of the control limits.

(iii) A gradual increase in dimensions indicate tool wear and further that the operator is not sure as to when the tool should be taken for grinding.

(iv) The initial low values and readjustment (at sample 5) indicate that the operator has difficulty in initial setting.

(v) Sample 4 indicates that attempts at adjustment has been made but not successful, the point falling outside control limit in both the charts.

(vi) The average dimension which should be zero (in new units) is actually 1.3 indicating higher dimension.

(vii) The actual average dimension achieved during the shift is much higher than 1.3. After sample 5, adjustment is made on the higher side and the average of points 5 to 16 works out to 1.8.

(viii) The range chart shows control except for sample point 4, the reason for which is known i.e. adjustment.

(ix) Since the range chart is exhibiting good control it would be possible to compute the ability of the process to produce the parts, that is the process capability which may be compared to specifications. In this case the factor is 0.7 (and the process can produce parts within ± 2.1 units. This may be compared to the process required that ± 2 units (0.002") which indicates that the machine is just sufficient to meet the requirement provided the average dimension is controlled adequately.

(x) It is also possible to calculate the proportion of axles which will have dimensions above the upper specification limit (i.e. 0.528) if the present average is maintained (that is 1.3 in new units or 0.527"); 26% of the items would have to be reworked.

(xi) In essence the operator is playing safe, in the sense he is working at higher dimension with the result no rejections would result, but rework has to be done.

The information obtained in one day give a great understanding of the process. The chart was further used to guide for proper initial setting, watching the process for adjustments, with the result the rework came down to almost nil within a week.

(ii) The second example relates to coil winding operations. The specifications were 4900 ± 100 turns. The quality control approach to the process control showed that the process could be worked to ± 50 turns. This information was used to adjust and trace the operators to aim at an average of 4850 turns and exercise control over the process so that the maximum was having turns around 4900, thus saving the costly copper wire.

(iii) The third example relates the experimental efforts to investigate a high number of rejections of phenol fibre components (used as insulating material). In the manufacture of the component the phenol fibre sheets are cut into sizeable strips, are created at a certain temperature and put into further operations. The factors and their levels are as follows :

Factor 1 Colour of phenol fibre sheet (A)	Black (A1) Dark (A2) Natural (A3)

Factor 2 Baking temperature (T)	300° F (Ti)
	320° F (T2)
	360° F (T3)
Factor 3 Baking time (t)	2 min. (t1)
	3 min. (t2)
	4 min. (t3)

A series of 27 experiments were carried out and analysis made to determine the optimum combination of factors which reduced the usual rejections rate of about 30% to about 6%.

(iv) This example refers to the manufactures of hoses used for vacuum braking purposes between the compartments of railway trains. In the manufacture of hoses the final operation is covering the hose with rubber coated duck cloth. As per specifications the cloth should be 'bias' cut, that is at an angle (as opposed straight cutting). It is also known that when warp and weft are in the usual pattern of weaving a bias cut of 45° would give maximum strength to the cloth. The company was using this angle and getting 28 pieces cut from a duck cloth piece. The characteristics of the hoses to be checked were "drop in vacuum" and 'shrinkage' after the test.

Observations revealed that if the cloth could be at another angle say (x°) the same length of cloth would yield 32 pieces. Since the angle was not specified in the specification any angle that would meet the specifications for the characteristics should be alright. The experimental design conducted revealed that there was no difference in 'quality' in terms of these two characteristics and hence the angle (x°) was adopted, giving an increase in production. The savings was substantial as the output per shift of hoses was of the order of 6 to 8 thousands.

Conclusion

The above presentation briefly presents the interrelationship of quality and productivity. When a visiting delegation from USA asked B. Tadano, Managing Director, Techno-Economic Society of Japan as to what factors were responsible for the rapid growth rate of Japanese productivity, he said the most influential factor in his opinion the practice of companywide quality control activities at the unit level. In the final analysis, it is to be emphasised that improving productivity through 'quality' approach is the only sound way for improving productivity.

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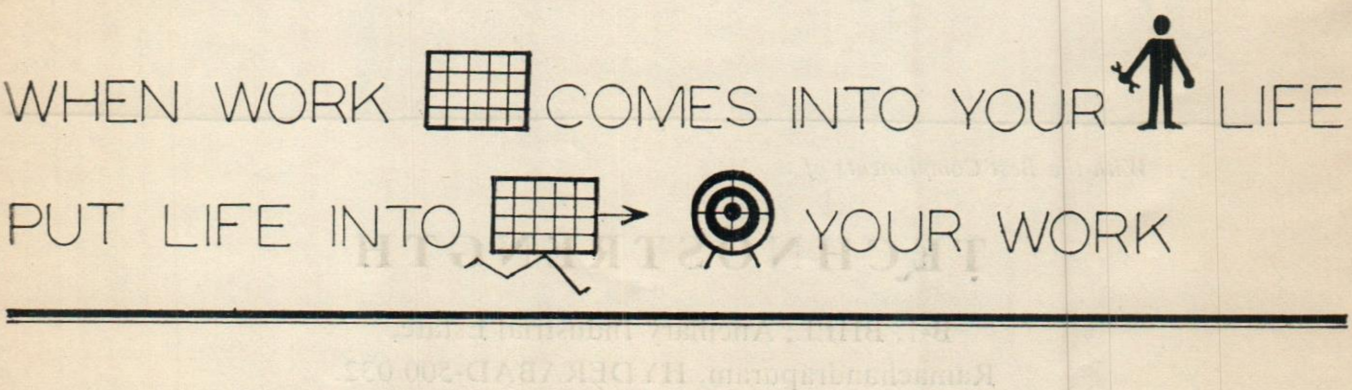
WHEN WORK COMES INTO YOUR LIFE
PUT LIFE INTO YOUR WORK

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EXECUTIVE READINGS

Growth Theory and Strategy: New Direction
L.C. Gupta

Published by: R. Dayal
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Reviewed by: Dr. N.C. Gupta,
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Various theories and strategies have been enunciated to increase per capita income in the Indian context. The desired breakthrough however, is yet to be achieved. In this connection one comes across L.C. Gupta's Growth Theory and Strategy—New Direction, to see as to how far his analysis could be relevant in the present day circumstances.

The book has been divided into three parts for purpose of analysis—Empirical Analysis, Reformulation of Growth Theory and Strategy, and Optimizing the Regional and Urban Patterns. The parts are suitably subdivided into nine chapters.

It is noteworthy that the author utilises inter-disciplinary approach to present his viewpoint, i.e., he takes advantage of the literature not only in economics but also sociology and geography. The major elements of growth strategy suggested by him are: (i) fastest possible rise in 'total factor productivity' in the major branches of economic activity, (ii) institutional arrangements to ensure that the emerging productivity gains get distributed, (iii) elimination of inflexibilities in the production of individual industries by removal of entry barriers to elicit speedy response to growth in demand, and (iv) discouragement to the erection of barriers to the mobility of capital and labour across regions or between industries. He presents a unified 'Systems' view of the growth process by examining the introduction of the manufacture of synthetic fibre to serve as a substitute for the natural cotton fibre (Chart 6.1, p. 106). One may agree to his views about the beneficial and retrogressive impacts that the system may result in. But to see the materialisation of 'beliefs, values, customs and kinship ties change', planned and systematic efforts are called for. Everyone has heard of the demonstration effects propounded by Nurkse. But, how much do these get materialised in different situations cannot easily be stated. There are so many leakages inherent in obtaining the desired momentum in economic activity.

The author suggests a number of factors for promotion of productivity gains and calls them as 'costless', being primarily matters of policy and ingenuity in organising the men and materials. One may, however, disagree on this crucial point. What is required in the circumstances as prevailing in the Indian context today is to see that the bureaucratic machinery works in the desired direction. The present book gives sufficient number of suggestions which could pave the way to organise the administrative system that befits the times.

Modern Indian Company Law
M.C. Kuchhal

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The author in this sixth revised edition of his book added a few more new decided cases with further clarity to the complicated legal provisions. The book is an asset in the sense, the intricate provisions of the companies Act, 1956 as amended upto date presented in a lucid and systematic manner, especially to suit the requirement of the University and Professional students appearing for the Examinations. The book as in original has been divided into 22 chapters on different aspects of companies Act very well organised having questions at the end of all the chapters. The select Bibliography is quite comprehensive giving an wide coverage of the related guidebooks and handbooks. In addition to various topics, 257 cases have been narrated for easy reference of the readers.

The point to be specifically noted is regarding a complete chapter of more than 40 pages on Management and Administration—a detailed analysis of all relevant section of the Company Law. Similar detailed treatment on Winding Up can also be seen in the said book.

The book goes into details of the amendments with explanations—in one word, a good text cum reference book for everyone on the subject. The credit must go to the author for making such a complicated subject easy to understand.

The get up of the book is simple though printed on the stationery supplied by NBT at concessional rate in turn helping in keeping the price to be reasonably low.

The Incredible Japanese
M.K. Rustomji
S.A. Sapre
Illustrated by V.B. Halbe

Published by
Macmillan India Ltd.,
Price : Rs 20/-
PP: 136

Reviewed by
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By 2000 AD. the experts say that Japan may emerge as the largest industrial power. Considering that Japanese economy has been growing at a rate of 10-12 percent a year, this does not seem improbable. Japan is now the largest producer in the world, of television sets, radios, cameras, ships and sewing machines and is among the leading manufacturers of steel and automobiles. Short of many natural resources and shattered by war, how could Japan rise to this position ? It is her people, their attitudes to work and methods of work. A study of these is an invaluable lesson to the people in the world. The present book entertainingly illustrated by Hable is a contribution in that direction.

Organised in 29 chapters, the book describes the economic development of Japan from the days of 2nd World War and traces the reasons for such phenomenal growth. The interesting thing about this contribution is that it studies the national psyche, the historical and geographical reasons for the development of the same, the consequent mores and customs such as widely prevalent life time employment, respect for seniority and age, the ringi system of group decision making etc. The book also discusses the current reality with changing mores and illustrates the same, with case studies of Hitachi and Nippon Oil Seal Ltd.

The book succeeds in giving interesting insights into Japanese way of work life to the reader. A must for all Man Managers. A good publication.

Productivity
1985, XXV, 4, 483-492

A Select Bibliography :

Quality Circles

P. RADHA KRISHNA MURTHY
A. K. DAS GUPTA

One of the reasons why India, has not been able to increase her exports, has been poor quality of the goods. To develop a competitive edge in the internatianal market, it is essential that the quality of the goods should improve and for this, the workers quality consciousness has to improve. In this regard, the quality circles are very relevant and our managerial personnel need to know more about the same. The present select bibliography on 'Quality Circles' is an endeavour in this direction.

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