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systematically studied. The technique of linear programming is based on the following four assumptions:

(i) A constant input-output ratio (or transformation coefficient) irrespective of the scale of operation.

(ii) That both the farm resources and the farm enterprises are divisible and additive in order to achieve the goal of maximization.

(iii) That the selection of one enterprise does not necessitate the selection of the other. In short, each farm enterprise is independent of the others.

(iv) That the number of enterprises adoptable is finite, and consequently choices and combinations can be made only within this finite number of enterprises.

Once the assumptions have been explicitely stated, thc problem of obtaining a solution is purely mechanical. In brief its aim is the same as that of budgeting. Of course it is a mathematical procedure and as such under this system the relationships connecting the resource supplies, institutional restrictions, and enterprises chosen as production possibilities are worked out in algebraic form. Consequently with a large range of alternatives available linear programming affords a mathematical solution to the problem of resource allocation where it becomes difficult to apply the budgeting technique. However the technique of linear programming requires a thorough practical training for the technician in its application to agriculture based on a higher educational level and a complete understanding of the assumptions involved. These reasons restrict the use of this technique in farm planning only by economically advanced countries. In underdeveloped countries like India where the educational level of the cultivators is comparatively low and the resource choices are also limited, the technique of budgeting in farm planning is to be preferred and is generally and widely used.

APPLICATION OF BUDGETING AND LINEAR PROGRAMMING IN FARM MANAGEMENT ANALYSIS

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Budgeting helps in the preparation of advance estimates of expenses and income of farm business. As a forward-looking and problem-solving approach, it is a popular tool of farm management analysis with the farm management economists. It involves programming, but as usually practised, it is not a highly systematic method and relies strongly on the judgment and initiative of the research worker. There is no guarantee that a most profitable combination of

enterprises will be discovered through budgeting. The new tool of Linear Programming has been evolved to serve this purpose.

Technically speaking, both linear programming and budgeting are based on the assumptions of linearity, finiteness, divisibility, additivity and independence. Both require essentially the same information in terms of specifications of restrictions of resources, input-output data and cost-price coefficients. Physical resources available for production define and delimit the enterprise choice and size. Budgeting, however, is seldom used to find out a unique production plan out of many alternatives. Ordinarily, it has been used to determine which one of the two production methods of farm organizations is the best. Linear programming, on the other hand, is used when the choice is to be made from among many alternatives, and when restrictions are of major importance in dictating entrepreneural action.

Some workers believe that budgeting is more useful a technique of farm management analysis than linear programming in under-developed countries. It is not a question of one tool versus the other. Whether the one or the other should be used, depends upon the objective in view. If a high degree of perfection is to be achieved, linear programming may be preferred, because it contains more obvious guides for knowing when an optimum allocation is achieved. Algebraic signs of a set of residual values in the computational procedure show when the optimum level is reached within the alternatives posed. Linear programming has, thus, an obvious advantage over budgeting in providing the objective guides, although knowledge of the physical and economic setting is necessary even here for the proper formulation of the problem.

To test the potentiality of both the tools—budgeting and linear programming—analyses were made for a specific farm situation in village Jodhan of Ludhiana district (Punjab). The relevant details of physical inputs and outputs were obtained by a survey. Keeping in view the resource requirements and soil capability, budgeting was done to provide a more profitable combination of enterprises to the cultivator. The alternative plan gives higher profits with minor changes in the combination of enterprises.[1]

For the same farm situation, linear programming analysis was used to maximize the linear function.

$$Z_0 = 294\ P_1 + 184\ P_2 + 162\ P_3 + 132\ P_4 + 200\ P_5 + 450\ P_6 + 302\ P_7 + 550\ P_8 + 230\ P_9$$

P_1 — Wheat Irrigated
P_2 — Wheat Unirrigated
P_3 — Wheat and Gram Mixture
P_4 — Gram Unirrigated
P_5 — Maize.
P_6 — American Cotton
P_7 — *Desi* Cotton
P_8 — Sugarcane
P_9 — Groundnut

The data on net prices are given in Appendix II. The resource restrictions were formulated as under:

1) $1\ P_1 + 1P_3 + 1\ P_8 \leq$ 15.50 acres of *rabi* land for Wheat Irrigated,
2) $1\ P_2 + 1\ P_4 \leq$ 3.00 acres of *rabi* land for Wheat and Gram unirrigated,
3) $1\ P_3 + 1\ P_8 \leq$ 13.00 acres of *rabi* land for Wheat and Gram Mixture,
4) $1\ P_8 \leq$ 7.00 acres of *rabi* land for Sugarcane,
5) $1\ P_5 + 1\ P_6 + 1\ P_7 + 1\ P_8 \leq$ 12.00 acres of *kharif* land for Cotton and Maize,

1. See Appendix I.

6) $1\ P_8 \leq$ 8.00 acres of *kharif* land for Sugarcane,

7) $1\ P_9 \leq$ 6.00 acres of *kharif* land for Groundnut,

8) $32\ P_3 + 32\ P_4 + 48\ P_8 \leq$ 554.00 Man-hours of labour from 15th March-14th April,

9) $32\ P_1 + 24\ P_2 + 20\ P_8 \leq$ 251.00 Man-hours of labour from 15th April - 30th April,

10) $24\ P_1 + 24\ P_2 + 8\ P_5 + 32\ P_8\ 16\ P_9 \leq$ 598.00 Man-hours of labour from 15th Oct. - 15th Nov.

11) $112\ P_1 + 56\ P_2 + 24\ P_3 + 600\ P_8 \leq$ 2,070.00 Man-hours of labour from Mid.-Nov.—Mid.-March.

12) $1\ P_6 + 1\ P_7 \leq$ 2.50 acres of picking labour for cotton,

13) $1\ P_6 + 1\ P_7 + 1\ P_8 \leq$ 9.00 acres irrigation capacity per week in April-June,

14) $10\ P_5 + 10 P_6 + 8\ P_7 + 20\ P_8 \leq$ 60.00 Tons of Farmyard Manure.

15) $60\ P_5 + 60\ P_6 + 50\ P_7 + 70\ P_8 + 75\ P_9 \leq$ 740.00 Cash available in *kharif* Season, and

16) $60\ P_1 + 40\ P_2 + 5\ P_3 + 5\ P_4 + 65\ P_8 \leq$ 532.00 Cash available in *rabi* Season

$Pi \geq 0$, which means all the enterprises are to be carried out at a positive level.

The input-output matrix[2] was built up and the following results were obtained in the final iteration[3] of the programming:

a) *Rabi:*
- i) Wheat Irrigated = 7.64 acres
- ii) Wheat and Gram Mixture = 7.54 acres
- iii) Gram unirrigated = 3.00 acres
- iv) Fodders = 2.00 acres

b) *Kharif:*
- i) American Cotton = 2.50 acres
- ii) Maize = 2.86 acres
- iii) Sugarcane = 0.32 acres
- iv) Groundnut = 5.28 acres
- v) Fodders = 3.50 acres

The mechanics of solution are not discussed here because it is given in most of the books on linear programming.

The total returns to the fixed resources worked out at Rs. 6,951.21, compared to Rs. 6,166.94 estimated through budgeting. Increase in profits comes solely from a re-arrangement of cropping. It does not assume any improvement in the methods of production. The better results obtained through linear programming are mainly due to objectivity involved in this analysis and because of the careful analysis of resource restrictions imposed by physical and economic setting of the problem.

Linear programming has been criticised by some workers for treating the factor-product prices and resources as subjective certainties while making the analysis. It is true that within the matrix of the given values some value is maximized. "While we recognize this abstraction, linear programming need not assume guilt beyond that of other techniques commonly employed for farm management analysis."[4] Again, this is not a serious limitation of the linear

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2. See Appendix III.
3. See Appendix IV.
4. Chester, O. McCorkle, "Linear Programming as a Tool in Farm Management Analysis," *Journal of Farm Economics*, December, 1955.

APPENDIX I

RETURNS TO THE FIXED RESOURCES FROM THE CULTIVATOR'S PLAN AND THE BUDGETED PLAN

	Cultivator's Plan				Budgeted Plan			
	Crop	Acreage	Net Returns per Acre (Rupees)	Total Returns (Rupees)	Crop	Acreage	Net Retuns per Acre (Rupees)	Total Returns (Rupees)
A. *Rabi:*	Wheat	6.00	294.00	1,764.00	Wheat	7.50	294.00	2,205.00
	Gram and Wheat Mixture	6.25	162.00	1,012.50	Wheat and Gram mixture	5.12	162.00	829.44
	Fodders	2.00	—	—	Fodders	2.00	—	—
B. *Kharif:*								
	Sugarcane	1.50	550.00	825.00	Sugarcane	1.25	550.00	687.00
	Maize	2.00	200.00	400.00	Maize	2.50	200.00	500.00
	Desi Cotton	0.75	302.00	226.50	American Cotton	1.50	450.00	675.00
	Groundnut	3.34	230.00	768.20	Groundnut	5.50	230.00	1,265.00
	Fodders	4.00	—	—	Fodders	4.00	—	—
	Total returns to the fixed resources			4,996.20				6,161.94

APPENDIX II

NET RETURNS PER ACRE TO THE FIXED RESOURCES OF THE FARM

Crop	Estimated Yield per Acre (Maunds)	Expected Price per Maund (Rupees)	Gross Returns (Rupees)	Variable Costs (Rupees)	Net Returns to the Fixed Resources (Rupees)
1. Wheat Irrigated	22.00	15.00	330.00	35.70	294.30
2. Wheat Unirrigated	14.00	15.00	210.00	26.50	183.50
3. Wheat and Gram Mixture	15.00	12.00	180.00	18.50	161.50
4. Gram on Unirrigated Land	12.00	12.00	144.00	12.50	131.50
5. Maize	20.00	11.00	220.00	20.00	200.00
6. American Cotton	12.00	40.00	480.00	30.50	449.50
7. *Desi* Cotton	11.00	30.00	330.00	28.50	301.50
8. Sugarcane	45.00	14.00	630.00	80.00	550.00
9. Groundnut	14.00	22.00	308.00	78.50	229.50

APPENDIX III

Resource Restrictions and Input-Output Coefficients

	C	O	294	184	162	132	200	450	302	550	230	2,504
	Resources	B	Wheat Irrigated	Wheat Unirrigated	Gram and Wheat Mixture Irrigated land	Gram Unirrigated land	Maize	American Cotton	*Desi* Cotton	Sugarcane	Ground-Nut	Σ
			P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	
1.	*Rabi* Land for Wheat Irrigated	15.50 Acres	1	0	1	0	0	0	0	1	0	18.50
2.	„ „ Wheat and Gram Unirrigated	3.00 „	0	1	0	1	0	0	0	0	0	5.00
3.	„ „ Gram and Wheat mixture Irrigated land	13.00 „	0	0	1	0	0	0	0	1	0	15.00
4.	„ „ Sugarcane	7.00 „	0	0	0	0	0	0	0	1	0	8.00
5.	*Kharif* Land for Cotton and Maize	12.00 „	0	0	0	0	1	1	1	1	0	16.00
6.	„ „ Sugarcane	8.00 „	0	0	0	0	0	0	0	1	0	9.00
7.	„ „ Groundnut	6.00 „	0	0	0	0	0	0	0	0	1	7.00
8.	Labour from 15th March-14th April	554 Man-Hours	0	0	32	32	0	0	0	48	0	666.00
9.	„ 15th April-30th April	251 „ „	32	24	0	0	0	0	0	20	0	327.00
10.	„ 15th Oct.-15th Nov.	598 „ „	24	24	0	0	8	0	0	32	16	702.00
11.	„ Mid. Nov.-Mid. March	2,070 „ „	112	56	24	0	0	0	0	600	0	2,862.00
12.	Picking Labour for Cotton	2.5 Acres	0	0	0	0	0	1	1	0	0	4.50
13.	Irrigation capacity per week (April-June)	9.0 „	0	0	0	0	0	1	1	1	0	12.00
14.	Farmyard Manure	60 Tons	0	0	0	0	10	10	8	20	0	108.00
15.	Cash in *Kharif* Season (Rs.)	740.00	0	0	0	0	60	60	50	70	75	1,055.00
16.	Cash in *Rabi* Season (Rs.)	532.00	60	40	5	5	0	0	0	65	0	707.00

APPENDIX IV

	C	O	O	O	O	O	O	O	O	O
Z	Resources	B	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}	P_{15}	P_{16}	P_{17}
1	2	3	4	5	6	7	8	9	10	11
162	P_3	7.537755	1.073166	.073164	0	0	0	0	0	0
132	P_4	3.0	0	1.0	0	0	0	0	0	0
	P_{12}	5.141983	—.878450	.121425	1	0	0	0	0	0
	P_{13}	6.679735	.194716	.194439	0	1	0	0	0	0
	P_{14}	6.320265	—.194716	—.194439	0	0	1	0	0	0
	P_{15}	7.679735	.194716	.194439	0	0	0	1	0	0
230	P_9	5.280352	—.129794	—.129705	0	0	0	0	0	0
	P_{17}	201.406981	—24.996079	25.002455	0	0	0	0	0	1
0	P_{16}	.719648	.129794	.129705	0	0	0	0	1	0
	P_{19}	296.379215	2.274652	2.274014	0	0	0	0	0	0
294	P_1	7.641981	.121550	.121425	0	0	0	0	0	0
	P_{20}	840.865035	77.445976	101.372068	0	0	0	0	0	0
	P_{22}	6.178906	.194639	.194489	0	0	0	0	0	0
550	P_8	.320265	—.194716	—.194439	0	0	0	0	0	0
200	P_5	2.858641	.389354	.389078	0	0	0	0	0	0
450	P_6	2.500000	.0	0	0	0	0	0	0	0
	Z	6951.213634	150.512972	120.593518	0	0	0	0	0	0
	Z-C	6951.213634	150.512972	120.593518	0	0	0	0	0	0

APPENDIX IV (Contd.)

	C	O	O	O	O	O	O	O	O
Z	Resources	P_{18}	P_{19}	P_{20}	P_{21}	P_{22}	P_{23}	P_{24}	P_{25}
		12	13	14	15	16	17	18	19
162	P_3	—.006100	0	0	0	0	0	0	—.014633
132	P_4	0	0	0	0	0	0	0	0
	P_{12}	.073004	0	0	0	0	—.000002	.000001	—.024287
	P_{13}	.066904	0	0	0	0	—.000002	0	—.038920
	P_{14}	—.066904	0	0	0	0	—.099999	0	.038920
	P_{15}	.066904	0	0	0	0	—.000001	0	—.038920
230	P_9	—.044596	0	0	0	0	—.079999	.013333	.025942
	P_{17}	3.406115	0	0	0	0	—.000067	.000037	—1.399602
0	P_{16}	0.44596	0	0	0	0	.079999	—.013333	—.025942
	P_{19}	.031780	1	0	8	0	.479997	—.213335	.454830
294	P_1	.073004	0	0	0	0	—.000002	.000001	—.024287
	P_{20}	32.103780	0	1	0	0	—.000654	.000349	—20.275325
	P_{22}	.066872	0	0	—1	1	—.000002	.000002	—.038899
550	P_8	—.066904	0	0	0	0	.000001	0	.038920
200	P_5	.133776	0	0	—1	0	.099997	.000002	—.077819
450	P_6	0	0	0	1	0	0	0	0
	Z	.175896	0	0	250.0	0	1.599592	3.067284	2.297832
	Z-C	.175896	0	0	250.0	0	1.599592	3.067284	2.297832

programming analysis, because, as many workers have shown, the optimum solution is not altered even if the factor-product prices change within reasonable margins and the price ratio remains almost the same.

SUMMARY

Budgeting and linear programming are both useful tools of farm management analysis. Depending upon the objective in view, one or the other may be used. Where the choice is to be made between many alternatives and high accuracy is needed, linear programming may be preferred. The computational procedure involved in linear programming provides guides that enable even a less skilled worker to reach an optimum solution. Linear programming is, therefore, a useful tool of farm management analysis even in under-developed countries.

MANAGEMENT AS A FACTOR IN FARM BUDGETING AND PROGRAMMING

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In a number of studies relating to the reorganization of farming systems through the use of budgeting and programming procedures, management has not been specifically recognized as an input factor; nor have reasonable adjustments been made in the enterprise budgets to indirectly take into account the varying levels of managerial ability. This applies not only to India and similar other countries with a short history of farm management investigations, but also to countries like the United States where farm management studies have recorded impressive gains over the past two decades. Until a few years back the chief contribution of American farm management research workers was limited to the furnishing of information of a technological nature in a *combined* farm, alongwith, in some cases, tentative forecasts of demand and supply situation and expected prices of inputs and output. "Farm Management research workers and teachers did not develop a systematic concept of management, define its tasks, nor develop a set of managerial principles. Their contribution was one of helping managers solve problems, not by making the problem-solving processes employed by managers more effective, but by furnishing data and information to managers. Historically, the data and information furnished to farmers by farm management men have tended to be rather technological, mainly from the fields of agronomy and animal husbandry."[1]

Yet, it is not the agricultural sector of the economy alone that is characterized by a delayed and still incomplete realization of the value of the human agent

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1. Glenn L. Johnson, Managerial Concepts for Agriculturists, Bulletin No. 619, Kentucky Agricultural Experiment Station, University of Kentucky, Lexington, 1954, p. 23.