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A MULTI-PERIOD PROGRAMMING MODEL SHOWING THE POSSIBILITIES OF CAPITAL FORMATION IN FARMING IN MAHARASHTRA AREA¹

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The concept of capital accumulation in farming may include availability of increased levels of working capital for purchase of fertilizers, manures, irrigation, seeds and animals, which is considered to be a part of operating capital. Another aspect is the increase in the levels of immovable capital like additions to buildings, water supply, machinery, fencing, bunding, fertility, etc. An economic balance of these two types permits the farmer to produce at optimum level and get maximum profits from the farm. The Farm Management Studies² in Maharashtra indicate that there is too much investment in land (82 to 85 per cent), while only 1.37 to 1.87 per cent was invested in farm buildings, 5.01 to 5.20 per cent in implements and machinery and 9.70 to 10.97 per cent in livestock.³ The farms in general lacked in farm buildings, implements and plant protection machinery and working capital for purchase of seeds, fertilizers, insecticides and fungicides and also for payment for additional labour.

The present study was taken up with a view to seeing the possibilities of capital formation and achieving a specified level of standard of living with existing resources of the farmer and with borrowing a specified sum. Continuous plans for a modal class farm in Nasik district were projected for a period of twelve years. This class with a farm size 5 to 15 acres, included 43.8 per cent of total sample farms, having 24.2 per cent of total cultivated area. Average size of farm family was 6 members having 2.2 adult working units. Other resources included 1.6 acres of irrigated land, a pair of bullocks and Rs. 400 working capital.

The data used for this study were collected by the Government of India under the Farm Management Scheme in Bombay (Maharashtra) State. Only the data collected by cost accounting method from 80 randomly selected farms during the year 1956-57 were used in the present study. Farm situations studied consider cropping plans with different levels of working capital, for ten-acre partially irrigated farms with levels of irrigation varying from 16 to 50 per cent of total farm size. Activities included in programming were 16 single crops and 5 double crops.

1. This paper is based on the author's unpublished Ph. D. dissertation on *Farm Planning and Possibilities of Capital Accumulation on Selected Farms in Nasik District of Maharashtra State, India—An Application of Multi-period Programming Procedures*, Kansas State University, 1964. The author expresses his gratitudes to Dr. Frank Orazem, Major Professor, Kansas State University, Manhattan (Kansas), U.S.A. under whose guidance the work was completed and also to Dr. (Mrs.) K. R. Bharadwaj for her helpful comments on the paper.

2. P. N. Driver and D. K. Desai : *Studies in the Economics of Farm Management in Bombay State, Report for the Year 1954-55*, p. 44.

3. There is no specific optimum structure of capital formation; but one has to consider the relative aspects in the sense that there is always certain proportion of investment which permits to realise optimum production with proper combination of resources. In earlier stages when capital is limited, programming promises high prospective marginal net returns to "working capital." The farmer would invest additional net returns in "working capital." Later on when adequate provision is made for it, expansion of irrigation facilities promises the highest marginal net returns. But in later stages, with higher capital levels, prospective returns to both these resources become limited and increase in the size of farm promises increased profits. Hence, an increase in acreage of dry land in later stages of capital formation is recommended.

The subsistence type situation forced the activities producing grain and fodder so as to provide a specified requirements of grain (16.17 maunds) and fodder (45 maunds) for the farm.

Analytical tools of budgeting, marginal analysis and linear programming were used at different stages of the study. Budgeting was used to project living and other fixed costs in farming. Programming was used to find out optimum plans with various resource restrictions, while marginal analysis was used for allocation of limited capital for various purposes by an individual farmer.

EXISTING STANDARD OF LIVING OF INDIAN FARM FAMILIES

The information gathered under National Sample Survey, Agricultural Labour Enquiry and the Rural Surveys gives a fairly good idea regarding itemised living expenditure of rural families in India. The data reveal that a very high proportion (70 to 80 per cent) of total income is spent on food. Other items get a proportionately smaller share. Average size of family is of five members and per capita annual expenditure on food varies from Rs. 100 to Rs. 130. As seen from Table I, items like medicine, education, etc., receive very little attention in the family budget.

Knowledge of the requirements of food for the farm families may help to formulate farm plans. Table I also gives an idea regarding the actual consumption of food and what the experts recommend as a balanced diet. Comparison of actual and balanced diet reveals that there is a large proportion of cereals in the diet while the rest of the items are below the standard requirements. Most of the protein requirements are met through pulses, which are not at the required level either. There seems to be a large gap in the case of both leafy and other vegetables, fats and oils, milk, fruits, fleshy foods and sugars. A high proportion of cereals in food indicate both poverty and poor nutrition.

Suggested balanced diet proposes caloric requirements of over 3,000 for an adult male unit. To achieve this standard, total expenditure per capita per year will be Rs. 295.41 at the 1956-57 price level. The programming in this study aims to achieve this level of dietary standard. This indicates that the existing expenditure on food of Rs. 100-125 has to be tripled within a period of 12 years. It is not only diet but also the general living standard that needs to be raised. The plan should also provide for additional expenditure on other items, like clothing, housing, education, medical care, etc.

PROJECTED LIVING COSTS FOR AN AVERAGE FARM FAMILY

On the basis of the recommendations for a balanced diet, per capita annual requirements of various items of food and total cost on food was worked out. This suggests a sum of Rs. 295 per head per year for balanced diet. The sample families consist of 6 members of which three are adults. Considering total requirement of 3,000 calories per adult and 2,400 calories per child per day, the family has 5.4 adult (1 child=0.8 adult units) units. Total expenditure for an average family for food thus comes to Rs. 1,593. Starting with current expenditure of Rs. 453 on food, the family should reach this level of balanced diet within

TABLE I—COMPARISON OF ACTUAL AND BALANCED DIET FOR AN ADULT UNIT WITH ITS ANNUAL COST

Item	Actual diet*			Balanced diet†				Total amount (Rs.)
	(ounces per day)	Annual cost (Rs.)	Balanced diet (ounces per day)	Estimated calories	Yearly requirement	Market rate (rupees per maund)		
1	2	3	4	5	6	7	8	
Cereals	16.59	14	1,400	4 maunds	16	64.00	
Pulses	2.39	3	300	68.5 lbs.	13	11.00	
Leafy Vegetables	0.71	4	60	2.75 maunds	8	22.80	
Other Vegetables	3.20	6	60				
Fats and Oils	0.52	2	500	46 lbs.	50	28.75	
Milk and Milk-products	2.81	10	250	2.85 maunds	20	57.00	
Flesh Foods	0.47	4	125	1.13 maunds	80	90.40	
Fruits	0.21	3	100	68.5 lbs.	15	12.84	
Sugar and Jaggery	0.71	2	225	46 lbs.	15	8.62	
Total	27.41	48	3,020			295.41	

* B. Rammurti : Agricultural Labour—How they Work and Live, Government of India, New Delhi, 1954, p. 47; Dool Singh, "Income and Expenditure Pattern in Some Rural Areas of Rajasthan," *Rural India*, April, 1960, p.147.

† C. G. Pandit and K.S. Rao : Nutrition in India, 1946-58, Indian Council of Medical Research, New Delhi, 1960, cited by P. V. Sukhatme, "Food and Nutrition Situation in India," Part II, *Indian Journal of Agricultural Economics*, Vol. XVII, No. 3, July-September, 1962, p. 21.

a 12-year period. Intensive research on nutrition gives idea about balanced diet but there is no specified standard regarding other items of expenditure in any society. These are mostly conventional standards for each social group. The projection of expenditure on various items will, therefore, be arbitrary, depending mostly on preferences of individual farm family. A projection of various costs for a 12-year period is shown in Table II.

MULTI-PERIOD MODEL FOR THE MODAL CLASS FARM

During the first year the farm operator has 8.4 acres of dry land, 1.6 acres of irrigated land, 74 days of June-July bullock labour, 110 days of October-November family labour and working capital of Rs. 400. The farmer can hire additional bullock and human labour if needed. He is a part of subsistence type of economy and would not like to run a risk of allocating all his resources for growing commercial crops. He, therefore, wants to include activities of growing cereal grains and fodder crops to provide 16.17 maunds of cereal grains and 45 maunds of fodder. Cropping plans for years 1 to 12 for a subsistence farm family are given in Table III. This may be called a multi-period model of annual expansion of farm plans by investing cumulative returns.

With given resources, the optimum plan for the first year will include the following levels of activities.⁴

Lucerne	..	..	..	..	..	1.6 acres
Bajri-gram	..	..	..	..	..	6.99 acres
Bajri	..	..	..	..	..	0.23 acres
Groundnut	..	..	..	..	..	1.18 acres
Bullock labour hiring	..	..	..	..	..	1 day

The plan for the first year offers a net profit of Rs. 1,417 after deduction of variable costs. This sum represents returns to the fixed factors, viz., the land, capital, bullock labour and family labour. Dry and irrigated land, working capital and bullock labour are all scarce resources, while family labour which has not been used up fully, is a free resource. Family labour as a free resource will not affect the net revenue even though its supply is increased or even decreased by eight days.⁵ In case of scarcity of resources, the revenue will immediately be increased or decreased as the levels of these resources change. During the

4. Source for input-output coefficients, D. K. Desai : Increasing Income and Production in Indian Farming—Possibilities with Existing Resource Supplies on Individual Farms (Application of Linear Programming Technique), The Indian Society of Agricultural Economics, Bombay, 1963, pp. 172-176.

5. In multi-period programming, the capital accumulated in previous periods can be utilised in periods to come. The excess resources in one stage do not form a constraint during that period due to lower levels of other resources. In ensuing periods, when levels of other resources are increased by investing the accumulated capital from previous periods, then the free resource in previous period may become scarce and form a constraint in programming. Out of 110 days of available family labour, only 101.61 days were utilised for the above plan. All other resources remaining constant, there was surplus of 8.39 days of human labour. The optimum plan suggested above will therefore remain unaffected even though there would be reduction of 8.39 days from actual supply of 110 days.

TABLE II—PROJECTED LIVING AND OTHER FIXED COSTS FOR AN AVERAGE FARM FAMILY IN INDIA*

Item of expenditure	YEARS											
	1	2	3	4	5	6	7	8	9	10	11	12
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Food	..	..	..	..	..	..	..	..	..	..	..	..
	453	453	550	700	700	1,000	1,000	1,026	1,250	1,350	1,540	1,600
Clothing	..	..	..	..	..	..	..	..	..	..	..	..
	125	125	125	130	130	150	150	150	175	200	200	300
Housing	..	..	..	..	..	..	..	..	..	..	..	..
	53	53	53	60	60	60	60	60	60	60	60	60
Fuel and Light	..	..	..	..	..	..	..	..	..	..	..	..
	7	7	7	20	20	20	20	20	20	20	20	30
Education	..	..	..	..	..	..	..	..	..	..	..	..
	11	11	20	40	40	40	200	200	300	300	20	20
Medicines and Health	..	..	..	..	..	..	..	..	..	..	..	..
	0	0	4	10	10	15	20	20	20	20	20	50
Social and Conventional needs	..	..	..	..	..	..	..	..	..	..	..	..
	92	92	92	75	350	75	75	75	75	75	75	75
Insurance	..	..	..	..	..	..	..	..	..	..	..	..
	0	0	0	0	0	0	0	0	0	0	100	100
Miscellaneous	..	..	..	..	..	..	..	..	..	..	..	..
	24	24	24	30	30	30	30	30	30	30	30	30
Total Living Costs	..	..	..	..	..	..	..	..	..	..	..	..
	765	765	875	1,065	1,340	1,390	1,555	1,581	1,930	2,055	2,065	2,265
Other Fixed Costs†	..	..	..	..	..	..	..	..	..	..	..	..
	248	84	400	1,000	725	675	510	484	135	10	0	0
Total Fixed Costs	..	..	..	..	..	..	..	..	..	..	..	..
	1,013	849	1,275	2,065	2,065	2,065	2,065	2,065	2,065	2,065	2,065	2,265

* The data for the first year are based on rural surveys and the data for the years 2 to 12 are projected estimates of living and other fixed costs for the typical farm family.

† Includes repayment of loan taken for purchase of oil engine and pumping set for irrigation.

TABLE III—FARM PLANNING IN RELATION TO VARIOUS LEVELS OF IRRIGATION ON A TEN-ACRE MODAL CLASS FARM IN NASIK DISTRICT

Plan No. (year)	Land (acres)		Level of working capital (Rs.)	Net returns (Rs.)	Optimum cropping plan		Labour hiring* (days)	Bullock hiring* (days)	* Marginal net returns to one unit				
	Irrigated	Dry			Crops	Acres			Capital (Rs.)	Irrigated land (Rs.)	Dry land (Rs.)	Human labour (Rs.)	Bullock labour (Rs.)
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1.6	8.4	400	1,417	Lucerne Bajri-gram Bajri Groundnut	1.6 6.98 0.23 1.18	-8.39	0.24	1.67	322.47	4.93	—	3.34
2	1.6	8.4	404	1,423	Lucerne Bajri-gram Groundnut	1.6 7.22 1.18	-7.22	0.24	0	578.74	64.71	—	1.25
3	3.0	7.0	573	2,114	Lucerne Bajri-gram Vegetables-Wheat	2.90 7.00 0.10	2.72	7.44	0	563.29	168.21	1.0	1.25
4-12	5.0	5.0	839	2,904	Lucerne Bajri-gram Vegetables-Wheat	3.94 5.00 1.06	11.88	19.87	0	563.28	168.21	1.0	1.25

* Unused labour.

first year, from the net revenue of Rs. 1,417 the farm family spends Rs. 765 for living costs and Rs. 248 for deepening of existing irrigation well, and construction of main water channels in areas which are to be brought under irrigation from third year. The farm family has decided to take advantage of facilities for borrowing from the Government for purchase of oil engine and a pumping set to be installed on the existing well. This would facilitate bringing additional area of 3.4 acres under well irrigation. The deepening of well and minor repairs for well are done by using Rs. 248 from net revenue from the first year. The expected marginal net productivity for working capital is very high and a farm family prefers to spend it in expanding irrigation facilities⁶ rather than in increased consumption. This leaves a total of Rs. 404 as working capital for the second year.

In the second year the resources are changed only in case of capital. There is an addition of Rs. 4 in working capital. The total of Rs. 404 will be optimum for the existing land resource. With the same restrictions, namely, producing a minimum quantity of food and fodder, the plan for the second year should include following activities.

Lucerne	..	..	..	..	..	1.6 acres
Bajri-gram	..	..	..	..	..	7.22 acres
Groundnut	..	..	..	..	..	1.18 acres
Bullock hiring	..	..	..	..	..	1 day

There is no significant change in the plan because of the additional working capital of Rs. 4. It, however, illustrates clearly the difference between a plan having limited capital and the one having optimum capital. Scarcity of capital forces more number of activities in the plan. Additional capital has made possible double cropping on 0.23 acre of land. Optimum capital thus serves as a double boon. It permits intensive use of other scarce resources like land and labour and also permits higher level of real activities.

Net revenue has increased only by Rs. 5. Marginal net productivity for the last unit of capital is zero and hence it is not a scarce resource in this plan. Marginal net productivity of both irrigated and dry land has a large increase. Irrigated land has a shadow price of Rs. 578.74, which is nearly a 100 per cent increase in value as compared to the first year plan. The shadow price for dry land has also increased from Rs. 4.93 to Rs. 64.71 per acre. Family labour is still a free resource. It can be used for intensifying activity of increased irrigation facilities.

During the second year (see Table II) the farmer spends the same amount on food and other living costs. Total expenditure on living cost remains at the

6. It is on the basis of expectation of realisation of net marginal returns from different resources at a particular stage that the family has to decide its priorities of investment of additional net returns. With limited capital, the marginal net returns in initial stages of development realised from investment in irrigation facilities were very high. It would naturally induce any farmer to postpone his desire for additional consumption. In later stages with availability of higher levels of capital, prospective returns to all the resources become limited. Expansion in size of farm and irrigation facilities were not possible due to technical and social reasons. The farmer would then prefer to increase expenditure on consumption rather than in farming.

level of Rs. 765. He spends a sum of Rs. 84 on remaining work of deepening the well and installing oil engine and pump. The remaining amount of Rs. 573 will serve as working capital for the third year. With the aid of new irrigation equipment purchased for Rs. 4,000, borrowed from Government, he brings an additional area of 1.4 acres under irrigation. His resource restrictions will now be as under.

Irrigated land	.. .. .	3 acres
Dry land	.. .. .	7 acres
Family labour (October-November)	.. .. .	110 days plus hired labour
Bullock labour (June-July)	.. .. .	74 days plus hired labour
Cereal grain requirement	.. .. .	16.17 maunds
Fodder requirement	.. .. .	45 maunds
Working capital	.. .. .	Rs. 573

The cropping plan for the third year includes increased level of lucerne. Vegetables-wheat replaces groundnut and level of bajri-gram has been reduced. It is necessary to hire both bullock and human labour. The net revenue for the plan is Rs. 2,114. The farmer now wants to increase his expenditure on food by nearly ten per cent. Even though he is entitled not to pay any instalment for repayment of loan during this year, he prefers to pay Rs. 600 as a first instalment and not to increase expenditure on food all of a sudden. This leaves a sum of Rs. 839, which serves as optimum level of capital for the expanded irrigation plan. Marginal net productivity of irrigated land is almost the same but that of dry land has increased nearly three times. Conversion of part of dry land into irrigated land has resulted in scarcity of dry land.

During the fourth year, the farmer brings two acres of additional land under irrigation. Thus he has brought all five acres of land under irrigation, the maximum limit that he can achieve. The resource restrictions now stand as follows :

Irrigated land	.. .. .	5 acres
Dry land	.. .. .	5 acres
Working capital	.. .. .	Rs. 839
Bullock labour (June-July)	.. .. .	74 days
Family labour (October-November)	.. .. .	110 days

} Plus hired labour.

Programming by simplex method gives the farm plan, which specifies increased levels of both lucerne and vegetables-wheat and decrease in level of bajri-gram. The level of labour and bullock hiring has also increased. This will be the final production plan for the farmer under subsistence conditions of farming. This plan gives him a net revenue of Rs. 2,904. There is no change in the level of mar-

ginal net returns for the scarce resources. Working capital requirements for all future optimum plans will be Rs. 839. The farmer has now the wider choice of disbursing his remaining revenue. He may increase expenditure on food and other items of living gradually; and pay the loan back by larger instalments, or pay a minimum specified instalment of loan and spend the rest of the revenue for a higher level of consumption. Ordinarily, a farmer would prefer to repay the loan as early as he can and avoid abrupt increase in living costs.

The farmer therefore repays Rs. 1,000 as an instalment of loan and increases his living costs by nearly Rs. 200. This is nearly 20 per cent increase over the previous year's living expenditure, and is mainly in food and education. There is no possibility of increasing the farm size or irrigated area and the farmer would now prefer to increase expenditure on food.

During the fifth year, resource restrictions and farm plan remain the same, but there is a difference in allocating expenditure. He spends a sum of Rs. 350 for marriage of his daughter. This is a conventional need and his choice indicator dictates him to spend this amount and repay only Rs. 725 as annual instalment of loan. An increase of 40 per cent in food expenditure and another 15 per cent in clothing and 50 per cent in medicines is a special feature during the sixth year. He repays an instalment of Rs. 675 of loan.

The seventh year's plan indicates an abrupt increase of 400 per cent on education.⁷ The eldest son, who completed his high school, was admitted to a college and Rs. 200 were provided for hostel and miscellaneous expenses. This is quite a scanty sum but the farmer will provide him grains, pulses and vegetables and this amount will serve the purpose. This expenditure will be Rs. 300 each for the ninth and tenth year. The secured income from farm would allow him to repay the remaining instalments of loan by the end of eighth year and gradually increase expenditure on food, clothing and other items of living costs as shown in Table II.

The loan of Rs. 4,000 borrowed for purchase of oil engine and pumping set with interest at Rs. 4.5 per cent per annum will be all repaid at the end of the eighth year. The farmer is free from debt and not only owns the engine and pump but has accumulated capital by way of increased capacity of well irrigation and has also raised his living standard considerably. He now gradually increases his expenses on food, clothing and education. He has educated his son which is also a formation of capital as it would now give him continuous returns by way of his earnings.

The farmer is, however, unable to reach the specified level of living standard, if land is the only source of available income. The standard of living achieved by him is, however, about 300 per cent higher compared to the first year of planning. Budgeting procedure permits the farmer to allocate the resources and income properly. If an unfavourable season reduces total revenue, he will adjust the

7. The priority order of investing additional capital was fixed as follows : (i) working capital; (ii) expansion of irrigation; (iii) expansion of size of farm; (iv) social and conventional expenses; (v) education; and (vi) increased consumption. The priorities fixed for the last three items are subjective but indicate a general trend while those for the first three items are based on the value of marginal net returns from additional capital investment.

on plan accordingly. He, however, realises the importance of keeping working capital for the coming year.

ESSENCE OF MULTI-PERIOD PROGRAMMING

The study of the above farming situations shows two stages of analysis. Cropping plans are established by the programming method, while projecting of living costs and investment needs budgeting and marginal analysis. A good combination of these tools of analysis gives a closer approach to reality. Programming plans for a particular year consider a static situation where resources remain constant and one does not depend heavily on expectations. In multi-period planning, accumulation of capital is possible. While projecting living costs, the family applies its choice indicator in specifying amounts to be spent on individual items. If expectations of prices and yields turn out correct, the farm family will spend on items of living costs as per their budget. But should the need for additional capital arise, the family can curtail expenditure on some items by postponing its purchases and use the funds as working capital. In the initial stages, if the farmer feels that by expanding the area under irrigation, he can get additional income of, say, Rs. 800, he postpones the marriage of his daughter for one year. He is thus in a position to have both these things done without either financial loss or loss of satisfaction.

Lucerne and groundnut seem to be the most promising crops. However, if several farmers grow lucerne it may decrease the price of lucerne considerably as dairy expansion is not likely to keep pace with expansion of the area under lucerne. Vegetables-wheat or cotton may, therefore, be the next best solution. This will necessarily curtail a large part of net revenue.

It can be seen from the above discussions that with the existing resources of land, labour and management of the farmer and permitting him to borrow only once a sum of Rs. 4,000 for irrigation machinery, it is possible to accumulate capital in the form of increased irrigation facilities, irrigation machinery and ability to maintain higher standard of living. It also permits him to educate his son at the college level and thus provide a life long source of higher income in the family.