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ECONOMIC IMPACTS OF RESOURCE USE OPTIMIZATION AND WATER AUGMENTATION IN FARMS OF PARAMBIKULAM ALIYAR PROJECT REGION*

Irrigation is one of the key factors of agricultural development and its impact on cropping pattern, farm income and employment in Indian agriculture has been extensively studied.[1] As elsewhere, water is the most restricting resource in Parambikulam Aliyar Project (PAP) region,[2] the locale of the present study. The ayacut of the PAP encompasses Pollachi, Udumalpet, Dharapuram and Palladam taluks of Coimbatore district in Tamil Nadu, which were drought-prone. Hence this project was initiated and became operational in 1962. As a part of the project, it was targeted to irrigate an ayacut land of 2.5 lakh acres. But owing to low and uncertain rainfall coupled with technical difficulties, even after 13 years of working, the project could achieve only less than 50 per cent of the targeted ayacut area.[3] The utility of the project is further restricted by factors, such as (*i*) water is let out only during July to December, when the demand for irrigation water is minimum in the study area as it exactly synchronises with the rainy season[4] and (*ii*) water is released for use by the farmers once in two years. For these reasons, the farmers are finding it difficult to profitably utilize their land

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1. (*i*) O. P. Anand, "Some Aspects of Optimum Benefits from Utilization of Irrigation Potential of Chambal Valley Project", *Indian Journal of Agricultural Economics*, Vol. XV, No. 4, October-December 1960, pp. 19-32; (*ii*) C. C. Maji and A. S. Sirohi, "A Case Study on the Financial Feasibility of Electrically Operated Deep Tube-Well in Illambazar Development Block in West Bengal", *Indian Journal of Agricultural Economics*, Vol. XXIV, No. 4, October-December 1969, pp. 181-190; (*iii*) R. S. Savale, "Intensive Development Approach to Agricultural Development: Role of Irrigation and Cropping Pattern in Agricultural Development", *Indian Journal of Agricultural Economics*, Vol. XXI, No. 4, October-December 1966, pp. 96-104; (*iv*) Selvarajan: *op. cit.*; (*v*) B. L. Shankarappa: Impact of Investment in Well Irrigation on Farm Employment Opportunities in Devanahalli Taluk, Bangalore District, Karnataka, M.Sc. (Ag.) Dissertation submitted to the University of Agricultural Sciences, Hebbal, 1975 and (*vi*) H. S. Vijayakumar, J. V. Venkataram and R. Ramanna, "Feasibility of Converting Unirrigated Farms to Irrigated Farms in Kangeri Circle of Bangalore South Taluka: A Simulation Analysis", *Financing Agriculture*, Vol. IX, No. 4, October-December 1978, pp. 27-30.

2. The PAP region was purposely selected as the study area, for the overall aim of the integrated study of which the present study was a part, undertaken by the Department of Agricultural Economics, Tamil Nadu Agricultural University was to evaluate the impact of this multipurpose river valley project on the socio-economic fabric of the community benefited by it. For the purposes of comparison a bench-mark survey had already been conducted in 1962, the year of commissioning of the project.

3. Government of Tamil Nadu: Parambikulam Aliyar Project, 1976.

4. Out of the total rainfall received in the years 1972-73, 1973-74 and 1974-75, the percentage of rainfall received during the project months, *i.e.*, July to December was 72, 84 and 70 respectively.

resources. Hence they are resorting to minor irrigation structures[5] by sinking wells.

In the context of investment in the development of irrigation systems, it becomes imperative to evaluate the impacts of such investments on income and employment on the farms in the study area. It also becomes necessary to use other resources judiciously along with water to harness the full potential of investment in irrigation. It may even call for reorganization of the existing resources. Information on these aspects for the study area is simply not available. The study on hand is an attempt in this direction.

For the purpose of this study it was hypothesized that (*i*) the farmers are not using their resources optimally and the optimum use of resources will improve income and employment on these farms, (*ii*) water augmentation can further improve income and employment prospects on these farms and (*iii*) water augumentation by sinking wells is profitable.

The objectives of the study are : (*i*) to empirically find out the effects of optimization and resource (water) augmentation on cropping pattern and intensity, labour (human as well as bullock) utilization and income of a representative farm, and (*ii*) to evaluate the economic worthiness of water augmentation by sinking a well on the selected farm.

METHODOLOGY

Sampling Procedure

The list of villages and sample farmers selected for the bench-mark survey (BMS)[6] provided the sample frame for the present study. In the BMS a total of 360 respondents uniformly spread over 12 villages in the four taluks of the study region, all selected by random sampling, were contacted. Considering homogeneity and contiguity, nine villages were selected from the original list and a sample of 90 respondents (from out of the old respondents) distributed over the nine villages in proportion to their gross cropped area, was randomly drawn. In case of shortage of old respondents in a village, a random selection of new respondents was done to cover the deficit. Thus a total of ten new respondents were contacted for covering the deficit.

Data

The data for the present study were collected from the selected respondents during the months of December 1975 and January 1976 through personal interviews with the help of pre-tested schedules. The data collected covered the agricultural years 1973-74 and 1974-75.

5. In general minor irrigation schemes are largely preferred to medium and major irrigation schemes because of their limited capital requirements, manageable size, short gestation period, vicinity of the service area and greater use of local talents and resources in their development. Vide P. R. Rao, "Irrigation and Cropping Intensity in India", *The Economic Weekly*, Vol. XV, No. 46, November 16, 1963, pp. 1902-1905.

6. Since the overall objective, as stated earlier, was to evaluate the impact of the PAP, it was found desirable to contact the same old respondents for the present study.

Tools of Analysis

For the purpose of our analysis a typical farm,[7] from among the sample farms, representing the average farm situation in the study area was selected. The profit maximization model of linear programming (LP) technique was used to find out the normative solutions. The model was

$$\text{Max } Z = Cx$$

$$\text{subject to,} \quad Ax \leqslant B \text{ and}$$

$$x \geqslant 0$$

Z = farm income over variable costs, which is to be maximized,
C = vector of objective function coefficients,
x = vector of activities,
A = matrix of input-output coefficients,
B = vector of resource constraints.

In tune with our objectives totally four optimum crop plans representing different resource situations were derived as detailed below:

(*i*) Optimum plan 1—Existing resources in the project year,[8]

(*ii*) Optimum plan 2—Existing resources+new well in the project year,

(*iii*) Optimum plan 3—Existing resources in the non-project year and

(*iv*) Optimum plan 4—Existing resources + new well in the non-project year.

These optimal plans were given by the solution of the LP problem through simplex method.

The comparison of the existing plan and optimum plans 1 or 3 would reveal the economic impact of reorganization of resources in the project or non-project years respectively. The impact of water augmentation could be evaluated by comparing optimum plans 1 and 2 for the project year and optimum plans 3 and 4 for the non-project year. Since it was believed that in the project years the well could deliver more acre-inches of water (groundwater recharge due to project water) than in the non-project years, the incremental income derivable from the well would be different, with greater income in the project years. Only to capture these effects, optimum plans 3 and 4 were drawn.

From the above, we could see that the methodology adopted in the present study differed from the earlier quoted studies in the sense that they had compared dry and irrigated farms to evaluate the impact of

7. The averages of cropping intensity, size of holding, bullock labour utilization, human labour utilization, cash expenditure, profit and utilization of water for all the sample farms were calculated and the farm which was very close to these averages was taken as the typical farm.

8. Project year represents the year when the PAP water is released for use by the farmers and non-project year, when the PAP water is not available for use by the farmers.

irrigation while in this study, it was evaluated by introducing a well in the selected farm. Such a methodology was followed by Vijayakumar *et al.*[9] in their study on impact of irrigation in Karnataka.

The economic worthiness of the well was evaluated through the Internal Rate of Return (IRR) method. The formula used for working out the IRR was

$$C = \sum_{i=1}^{n} \frac{A_i}{(1+r)^i}$$

where C = initial capital outlay on the new well,

A_i = net incremental benefit at the end of year i,

r = internal rate of return,

n = life period of the project.

Activities and Constraints Used in the Model

The activities included in the model were only crop enterprises that were either grown and/or improved/hybrid varieties recommended for the study area. Dairying was not considered as an activity as commercial dairying was found to be very limited.

Land and water were found to be the most restricting resources on the farm and hence the resource vector had a set of land constraints for different seasons and types of land. Separate land constraints were also specified for three crops, namely, tomato, chrysanthemum and onion to reflect managerial ability and farm-home requirements. As regards the water constraint, it must be stated that the region benefits by way of south-west and north-east monsoons in the months of April to November in general and also by project water during the months of July to December in the project years, hence water was not found to be restricting from April to December in the project years and in the non-project years. With the existing irrigation structures with the help of monsoons taking care of the irrigation requirements of the selected farm from April to November, water was not found to be restricting during these months. Then based on water availability and water requirement data, we found that water availability was a restriction for the month of March in the project years and for the month of December and March in the non-project years. Though it might be felt that specifying constraints for the entire season December to March might better capture the effects of water constraints, yet we felt that specifying monthly constraints as had been done in this study would in no way affect the results, given the characteristics of the selected farm. Further while fixing the water constraints, the reduction in availability of water from the existing irrigation structures in the absence of PAP water had been adequately taken care of.

9 *op. cit.*

The input-output coefficients and the net value products for different activities were derived either from the data collected on the sample farms or based on the recommendations of Department of Agriculture and in consultation with field officers.

RESULTS AND DISCUSSION

The impact of resource use optimization and water augmentation was sought to be evaluated in terms of cropping pattern, cropping intensity, human and bullock labour utilization, farm business income, family labour income, labour earnings per man-day and gross and net income.[10] The cropping pattern and cropping intensity under different plans are presented in Table I and the other measures are presented in Table II.

Before we compare the different plans it might be mentioned that the typical farm selected for planning had 13 acres of operational land holding with seven acres under garden land and six acres under dry land. The irrigation requirements of the garden land would be met partly by PAP water and partly by existing irrigation structures in the project years and fully by the existing irrigation structures in the non-project years. Because of this there would not be much difference in the water availability between project and non-project years[11] except for the fact that water becoming a constraint in the month of December also in non-project years. In view of the availability of water from well and project during project years, one may suggest to channelise water to dry lands at least during project years. This is however not possible as the dry land is at an elevated place. Further, the suggestion to sink a well in the farm would essentially convert about 3.50 acres of dry land to garden land. However, its impact had been measured for the farm as a whole as it now becomes the planning environment.

Discussions on the impacts of resource use optimization and water augmentation have been confined mostly to the project years, though references have been made about the effect of the well in the non-project years on several occasions.

A. *Effects of Resource Use Optimization and Water Augmentation on*

1. *Cropping Pattern*

The cropping pattern, existing and as suggested by the different

10. In working out the various income measures, the cost concepts used in farm management studies, namely, cost A1/A2, Cost B and Cost C(2) were used. The various income meaures are related in the following way:

(*i*) Gross income = Total income received from the crop enterprises.
(*ii*) Net income = Gross income — Variable cost (cost of cultivation expenses).
(*iii*) Return to variable capital invested = Gross income/variable cost.
(*iv*) Farm business income = Gross income — Cost A1/A2.
(*v*) Family labour income = Gross income — Cost B.
(*vi*) Labour earning per man-day $= \frac{\text{Family labour income} + \text{paid wages of all labour}}{\text{Employed man-days}}$

11. Because of this we expected that there would not be any substantial differences in the different economic parameters between project and non-project years. Hence no attempt has been made to evaluate the impact of the project water on the selected farm.

optimum plans, is presented in Table I. A comparison of existing plan and optimum plan 1 revealed that resource use optimization while suggesting the growing of improved varieties of some currently grown crops on the farm, also introduced new crops. All currently grown varieties of crops with the exception of groundnut (POL-1) got replaced in the optimum plan because of their low net value products. Further, it could be observed that optimization favoured growing more number of crops as compared to the existing plan, thereby suggesting trends towards diversification. A comparison of optimum plans 1 and 2 and/or 3 and 4 revealed that water augmentation had not brought about any basic change in the crop mix as suggested in the optimum plan 1 but had favoured increasing the acreage under cotton, sugarcane and maize, thereby suggesting trends towards specialisation on these crops. It was also found that in the optimum plans 1 and 2, about 2.83 acres and 4 acres of garden land respectively were left fallow during February and March, because of water restriction. Hence it is suggested that short duration pulse crops like gram could be grown to utilize this fallow land also.

2. *Cropping Intensity*

The cropping intensity of the existing plan was 169 per cent and by optimal resource use it could be increased to 195 per cent(see item 15 of Table I). It could be observed that the gross cropped area in dry land had nearly doubled by optimization while in garden land it

TABLE I—CROPPING PATTERN UNDER EXISTING AND DIFFERENT OPTIMUM PLANS

Sr. No.	Crop activities	Area (acres)				
		Existing plan	Optimum plan 1	Optimum plan 2	Optimum plan 3	Optimum plan 4
A.	Garden land					
1.	Cotton MCU 5 (July-Jan.)	7.00	—	—	—	—
2.	Cholam CSH 5 (Feb.-May)	6.00	—	—	—	—
3.	Onion Co. 1 (May-July)	2.00	—	—	—	—
4.	Cotton Varalakshmi (July-Jan.)	—	4.38	6.00	3.21	3.50
5.	Sugarcane (Jan.-Jan.)	—	2.17	4.50	2.17	4.50
6.	Maize Ganga 5 (April-July)	—	2.83	4.00	2.83	4.00
7.	Onion Co.2 (May-July)	—	1.50	1.50	1.50	1.50
8.	*Ragi* Co.10 (Feb.-May)	—	1.50	1.50	1.50	1.50
9.	Tomato Co.2 (Feb.-June)	—	0.50	0.50	0.50	0.50
10.	Dry Cholam Co.18 (Sept.-Dec.)	—	—	—	1.62	2.50
B.	Dry land					
11.	Groundnut POL-1 (Apr.-July)	5.00	6.00	2.50	6.00	2.50
12.	Cholam rainfed (Sept.-Dec.)	2.00	—	—	—	—
13.	Cholam mixture (Sept.-Feb.)	—	6.00	2.50	6.00	2.50
14.	Gross cropped area	22.00	25.33	23.00	25.33	23.00
15.	Cropping intensity	169.23	194.85	176.92	194.84	176.92

had actually decreased. This decrease in garden land could be attributed to the introduction of sugarcane, a long duration crop. However, it might be puzzling to note that optimization leads to near doubling of cropping intensity in dry land, resulting from a fuller utilization of available land in both the seasons. The general tendency in dry lands was that the farmers would use their land to the maximum extent possible subject to constraints of nature and that any resource use optimization would lead to only a marginal increase in the cropping intensity in dry land. The all pervasiveness of risk in dry land would force farmers not to cultivate the entire land with a view to minimize unexpected losses. This might be one of the reasons as to why the farmer had cultivated only two out of six acres of dry land in the second season (Table I). Considering the prevailing situation, we feel that the optimum plan acreage under cotton mixture in the *rabi* season has to be discounted to a level consistent with the subjective estimation of the effects of the above factor. This however had not been attempted here due to paucity of clear-cut information on these aspects. That such constraints had not been explicity stated in our LP model would not undermine the utility of our optimum plans as most of the constraints faced by the farmer had been captured fairly well by the model. Water augmentation however had decreased the cropping intensity to 177 per cent mainly because of the fact that there had been a greater increase in the acreage under sugarcane than under other lesser duration crops. Such a result was found to be in conformity with the observation of Rao,[12] who found that changes in the cropping intensity in different States were not uniform with irrigation development because of annual crops like sugarcane and banana.

3. *Bullock Labour Utilization*

Resource use optimization increased the total bullock pair days employed by 18 pair days (an increase of about 17 per cent) and water augmentation by 17 pair days (13.08 per cent) in the project years and by 12 pair days (9.68 per cent) in the non-project years (see item 1 of Table II). While crop diversification accounted for the increased bullock labour utilization by optimization, specialisation on more labour intensive irrigated crops in place of less labour intensive dry crops accounted for the increases due to water augmentation.

4. *Human Labour Utilization*

The number of man-days employed under the different plans are presented in item 2 of Table II. The man-days utilized at present was 1,183 and by resource use optimization, it would increase by 189 man-days (15.98 per cent) and by water augmentation, it would increase by 300 man-days (21.87 per cent) in the project years and 241 man-days (18.47 per cent) in the non-project years. Similar reasons, as described

12. *op. cit.*

TABLE II—EFFECT OF RESOURCE USE OPTIMIZATION AND WATER AUGMENTATION ON CERTAIN ECONOMIC PARAMETERS

Sr. No.	Particulars	Existing plan	Optimum plan 1	Optimum plan 2	Optimum plan 3	Optimum plan 4	Effect of resource use optimization	Effect of water augmentation	
								Project year	Non-project year
1.	Bullock labour utilization (pair days)	112	130	147	124	136	18 (16.70)	17 (13.08)	12 (9.68)
2.	Human labour utilization (man-days)	1,183	1,372	1,672	1,280	1,521	189 (15.98)	300 (21.87)	241 (18.47)
3.	Gross income (Rs.)	43,073	54,258	65,416	50,386	59,442	11,185 (25.97)	11,158 (20.56)	9,056 (17.97)
4.	Net income (Rs.)	23,151	30,817	37,803	28,227	34,080	7,666 (33.11)	6,986 (22.67)	5,853 (20.74)
5.	Return to variable capital (Rs.)	2.06	2.31	2.37	2.27	2.34	0.25 (12.14)	0.06 (2.60)	0.07 (3.08)
6.	Family labour income (Rs.)	11,022	19,500	24,142	17,022	20,587	8,477 (76.91)	4,642 (23.81)	3,565 (20.95)
7.	Farm business income (Rs.)	18,783	27,260	33,503	24,775	29,949	8,477 (45.13)	6,242 (22.90)	5,174 (20.89)
8.	Labour earnings per man-day (Rs.)	14.32	19.21	19.44	18.30	18.53	4.89 (34.15)	0.23 (1.20)	0.23 (1.26)

Figures in parentheses indicate percentages.

under bullock labour utilization, could be attributed to the increases in human labour employment by optimization and water augmentation.

The temporal distribution of labour utilization under different plans is presented in Table III. In all the three plans, namely, existing and optimum plans 1 and 2, the peak month of labour utilization was found to be December because of the harvesting operations for cotton in the existing plan and that of cotton and sugarcane in the optimum plans. A further perusal of the table revealed that resource use optimization had brought about a more even distribution of labour utilization [coefficient of variation (CV) : 56 per cent] over the existing plan (CV : 77 per cent). However, water augmentation had the effect of uneven distribution (CV :72 per cent). These were the results of diversification and specialisation effects of optimization and water augmentation.

As discussions have revealed, both optimization and water augmentation have good potentials in generating additional employment on the farm. With labour being in surplus in the study area, the introduction of minor irrigation schemes, besides increasing productivity and income, would also help in absorbing the unemployed/under-employed labour in the area.

TABLE III—MONTHLY HUMAN LABOUR UTILIZATION UNDER DIFFERENT PLANS

(*man-days*)

Sr. No.	Month	Existing plan	Optimum plan 1	Optimum plan 2
1.	January	98	158	199
2.	February	12	77	80
3.	March	20	33	48
4.	April	66	93	85
5.	May	100	106	94
6.	June	40	97	105
7.	July	122	190	214
8.	August	84	75	95
9.	September	114	83	103
10.	October	104	90	120
11.	November	114	95	108
12.	December	309	275	421
13.	Total	1,183	1,372	1,672

5. *Effects on Income*

Resource use optimization would increase the gross income by 25.97 per cent, net income by 33.11 per cent, family labour income by 76.91 per cent and farm business income by 45.13 per cent. The percentage net income increase was higher when compared to the percentage gross income increase because of a lesser increase in cash expenses, about 12 per cent. This was further reflected in the increase in return to variable cost from Rs. 2.06 in the existing plan to Rs. 2.31 in the optimum plan 1.

The effect of water augmentation was to increase the gross income by 20.56 per cent, net income by 22.67 per cent, family labour income by 23.81 per cent and farm business income by 22.90 per cent. The return to variable capital would increase only marginally, *i.e.*, from Rs. 2.31 to Rs. 2.37 because of the fact that both the optimum plans when compared, suggested basically the same crops and this marginal increase was brought about by the replacement of a relatively lower return to variable cost ratio for dry crops in the optimum plan 1 with a higher return to variable cost ratio for irrigated crops like sugarcane and cotton in the optimum plan 2.

The labour earnings per man-day would increase from Rs. 14.32 to Rs. 19.21 by resource use optimization and from Rs. 19.21 to Rs. 19.44 by water augmentation. Only a marginal increase in the labour earnings per man-day had been noticed due to the additional well, for similar reasons discussed earlier in this study.

The above discussions reveal that there exists considerable scope for increasing incomes and employment in the study area through resource use optimization and water augmentation. However, it was found that the farmers in the study area were operating at sub-optimum levels. The non-awareness of the optimum plans coupled with factors like lack of awareness of the improved varieties and their technology, difficulties in procuring additional resources, lack of adequate infrastructure for sustaining the increased demand for modern inputs, etc., were acting as obstacles in fully realising the potentials of these optimal plans.

B. Economic Evaluation of the Well

Water being the most restricting resource in the study area, next to land, it pays to increase its availability by tapping the underground water through sinking of wells. The marginal value productivity (MPV) of water was found to be Rs. 29 per acre-inch, which means that an additional acre-inch of water would yield an additional net income of Rs. 29.

Since water augmentation could be carried out only at a cost, by way of initial investment on the well, an economic evaluation of the well is necessary to assess whether the additional benefit derived from the well is commensurate enough to make the investment on it a worthwhile proposition. The IRR technique has been utilized for such an evaluation in the present study.

From the survey data, it was found that the cost of sinking a well with pumpset and development of irrigation structures would be Rs. 25,000. Hence this amount had been taken as the initial investment cost which could be met by the farmer either from his own capital or from loans obtained from lending institutions at 11 per cent rate of interest. For the purpose of this analysis, the economic life of the well was fixed at 20 years, though its services would be available even for further years to come. The maintenance/replacement cost of the well, pumpset, etc., was fixed at 2 per cent of the initial investment per year. No salvage value was assigned to the well at the end of 20th year.

As stated earlier, the additional net income the farm would derive from the additional well would be Rs 6,986[13] in the project years (compare the optimum plans 1 and 2) and Rs. 5,853 in the non-project years (compare the optimum plans 3 and 4). If the farmer used his own capital for sinking the well, the additional cost he would have to incur would be only the maintenance cost. Under such conditions, the IRR of the investment on the well was worked out to be 23.58 per cent. Since the estimated IRR is far greater than the current rate of interest of 11 per cent, the project is worthy of consideration and implementation.

13. As we are taking the differences between the optimum plans only, the reduction in income that might occur due to constraints explained earlier in implementing the optimum plans gets cancelled.

The IRR estimated above is one of static concept both for factor costs and product prices. But in practice both may vary over time. Under such conditions the sensitivity of the project has to be analysed considering these changes. In order to evaluate the worthiness of the well under these changing conditions, the effect of a 10 per cent change in both factor costs and product prices and their various combinations on IRR was worked out and presented in Table IV. It could be seen from the table that even under the most adverse situation, namely, 10 per cent increase in factor costs and 10 per cent decrease in product prices, which might not normally occur, the IRR was found to be 17.75 per cent, which was well above the current rate of interest of 11 per cent.

TABLE IV—SENSITIVITY ANALYSIS OF THE INVESTMENT ON NEW WELL

Sr. No.	Factor costs	Product prices	IRR
1.	Original	Original	23.58
2.	Original	10 per cent increase	28.02
3.	Original	10 per cent decrease	19.13
4.	10 per cent increase	Original	21.98
5.	10 per cent decrease	Original	25.06
6.	10 per cent increase	10 per cent increase	26.08
7.	10 per cent decrease	10 per cent decrease	20.70
8.	10 per cent increase	10 per cent decrease	17.75
9.	10 per cent decrease	10 per cent increase	29.44

If the farmer obtained a long-term loan of Rs. 25,000 for digging the well, the repayment of principal and interest should also be taken into consideration as cash outflow.[14] Under this changed context, the IRR was worked out to be 8.76 per cent which indicated that the farmer would get a net profit of 8.76 per cent from the well even after repaying the loan amount with interest.

14. In our analysis the period of repayment of loans for sinking wells and installation of pumpsets was fixed at nine years. It was also assumed that the additional income would be realised only at the end of the year after the well is sunk and so the farmer had to pay only the interest for the first and second year, with the repayment of loan at equated instalments of Rs. 4,510 for capital and interest commencing from the third year onwards and extending upto the eleventh year.

Also refer to the following studies: (*i*) C. S. Barnard and J. S. Nix: Farm Planning and Control, Cambridge University Press, Cambridge, 1973, pp. 45-47; (*ii*) S. M. Patel and K. V. Patel: Economics of Tube-Well Irrigation, Faculty for Management in Agriculture and Co-operatives, Indian Institute of Management, Ahmedabad, 1971; and (*iii*) S. M. Shah, "Cropping Pattern in relation to Irrigation," *Indian Journal of Agricultural Economics*, Vol. XVIII, No. 1, January-March 1963, pp. 154-160.

The above analysis clearly revealed that the investment on the well was found to be sound either when the farmer uses his own capital or borrows it from the lending institutions. Since water is the most restricting resource in the study area, the question of comparing the investment on the well with other possible investments on the farm does not arise. Besides increasing the farm income, it would also help to stabilise the farm incomes in the study area.

CONCLUSIONS AND POLICY IMPLICATIONS

The above discussions clearly point out that there exists ample scope for increasing farm incomes and employment through resource use optimization and water augmentation. The information on optimum plans computed will be useful for policy makers to evolve regional schemes for development. The results of the study can be utilized by the credit agencies to assess the credit needs, both short-term and long-term of the farmers and the risks they have to bear in lending to the farmers of the region. Based on our analysis, certain policy instruments could be identified and their implications can be stated as follows:

(*i*) The optimum plans suggest the adoption of high-yielding varieties which necessitate the dissemination of technical know-how by proper extension technique and training.

(*ii*) The use of capital intensive technology is being suggested by the optimum plan. So adequate supply of modern inputs at right time at fairly competitive price should be made available.

(*iii*) The scope for water resource development and use is encouraging as revealed through the high MVP for irrigation water and a high IRR for the well. So water supply could be augmented by a rational well sinking programme through regulation and financial assistance. Further, the possibilities of lifting the system of lending water for irrigation in alternate years from the project may be examined.

(*iv*) Finally farm planning as an extension tool could be popularised by the extension agencies to convince the farmers on the need for changing the crop mix in the region.

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