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Research Paper

Impact of Irrigation Water on Net Farm Income in Three Regions of Somasila Project in Andhra Pradesh: A Linear Programming Approach

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ABSTRACT

The present study is an attempt to analyze the possibilities and prospects of increasing the net farm income by better resource allocation through optimum enterprise system. Somasila command area was purposively selected for the present study, as it is one of the agriculturally advanced command area of Andhra Pradesh. A multi stage stratified purposive cum random sampling procedure was adopted to the present study. The entire command area divided into three regions viz., head, middle and tail regions. From each region first two mandals with maximum command area were purposively selected. From each mandal two villages were selected. From 12 villages, five each from small and large farmers were selected at random. The number of farmers selected from each village was ten and that total number of farmers selected for purpose of present study was 120. The results of the study revealed that there exists sub-optimal allocation of resources in the existing plans of small and large farmers. The process of optimization under different water supply conditions resulted in the improvement in the net farm returns of both the categories of farmers in the study area. However, the optimum model developed at existing water availability resulted in higher net farm returns as compared to other models developed at 10, 20 and 30 percent reduction in the water supply on small and large farms of head, middle and tail regions.

HIGHLIGHTS

- There is greater scope for increasing the net farm returns and resources through systematic farm planning under the existing water supply and resource base on the farms of the three regions.
- The process of optimization under different water supply conditions resulted in the improvement in the net farm returns of both the categories of farmers.

Keywords: Optimum Plans, Rational Resource Allocation, Linear Programming Model

The importance of water as a valuable resource for agriculture can never be over emphasized. The increasing need for crop production for the growing population is causing the rapid expansion of irrigation throughout the world. The area under irrigation in India was only 19.4 M ha in 1947 and has increased to 22.6 M ha before the five-year plan commenced i.e. 1950-51. Out of about 141 M ha of net area sown in the country, about 65 M ha (or 45 percent) is presently covered under irrigation.

Andhra Pradesh is endowed with many major rivers, important among them being Godavari, Krishna, Vamsadhara and Penna. The states share of dependable flows at 75 per cent dependability from the river system is estimated at 2746 TMC. This breaks up into 1480 TMC from the Godavari System, 811 TMC from Krishna, 98 TMC from the

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Pennar and the rest from other smaller rivers. Before independence, the total irrigation potential created was 2.704 M.ha upto 1951. After independence, high priority was given to irrigation development for rapid economic growth and planned irrigation development was started to achieve the goal. As a result the investments on irrigation schemes in the states increased substantially. In the span of 46 years, from 1951-52 to 1992-97 an additional irrigation potential of about 2.26 M.ha has been created bringing the total to 4.963 M.ha.

Water being a limited resource, its efficient use is very vital and basic to the very survival of the ever-increasing population. Every effort must be made to make the best use of available water so as to make possible a higher level of continuous production per unit volume of water, per unit area of cropped land and per unit time.

The main concern of productive agriculture is the effective and efficient supply of water to crop fields. Since irrigation potential is created at huge cost, it is necessary to derive maximum benefit from the created potential. A large amount of water is wasted in conveyance and distribution systems. As such 50 per cent of water is reached to field from major reservoirs and the efficiency of the irrigation system is only 35 per cent and major irrigation schemes are running sub optimally.

In agriculture as in any other business, the efficiency is achieved by the optimum utilization of resources. Optimum allocation of land and other resources is designed as to what crop activities to undertake, how much land to allocate to each crop activity and what method and combination of inputs to use on each crop, so that net farm returns are maximum. Increasing costs of agricultural inputs and dwindling profitability of crop production has been making agriculture a loosing proposition. In view of this, it is necessary that the available inputs should be used economically and efficiently. The efficiency of farming depends on such combination of resources that is most economical to secure a given output. The relation between the money value of outputs and inputs is thus a measure of efficiency. The higher the output per unit of input, the greater is the efficiency of a given resource and conversely greater the efficiency of resources, the greater would be the output. The maximization of efficiency is therefore, a condition for the maximization of income. The efficiency of each factor input in maximized when its contribution to production is maximum. The equilibrium of factor inputs, is denoted by the point at which the marginal productivity of the factor inputs is equal to their prices. That is, at this point an optimum combination of factors making for the highest efficiency is achieved. The rational use of resources on farm can be achieved by determining scientific optimal enterprise mix resulting in increased farm returns and employment.

This study was an attempt to analyze the possibilities and prospects of increasing the net farm income by better resource allocation through optimum production pattern of crops.

METHODOLOGY

The present study was undertaken in the Somasila Project command area, a large surface irrigation system in Nellore district of Andhra Pradesh with the specific objective of determining the income prospects of farmers through optimum reorganization of resources. It was selected purposively in view of the existences of variations in water availability at different regions of farm.

A multi stage stratified purposive cum random sampling procedure was adopted to the present study. The entire command area divided into three regions viz., head, middle and tail regions. From each region first two mandals with maximum command area were purposively selected. All the villages in the selected mandals based on command area were arranged in descending order and the first two villages from each mandal were selected for a detailed study. The list of farmers from the selected 12 villages of three regions of command area, were obtained from the village officials. From the list of farmers in each village, five each from small and large farmers were selected at random. Thus, the number of farmers selected from each village was ten and that total number of farmers selected for purpose of present study was 120. The data on inputs and outputs of crop enterprises were collected from the respondents for the agricultural year 2003-2004.

The crops grown by the sample farmers were paddy (1001), Paddy (1009), sunflower (Morden), sunflower (Hybrid), groundnut (JL-24), bajra, sugarcane, brinjal, in kharif season and paddy, cotton, chillies, cowpea, greengram and gingelly in *rabi* season.

Mathematical Formulation of the Model

In linear programming analysis, a linear function of a number of variables is to be maximized subject to a number of constraints in the form of linear equalities and inequalities. In mathematical form, one-year (two seasons) linear programming model can be expressed in the following way.

$$\text{Maximize } Z = \sum_{j=1}^{n} C_j X_j$$

j = 1 to n activities

Subject to following constraints;

1. $\sum_{j=1}^{n} a_{ij} X_j > b_i$ (i = 1, ……….K constraints)
2. $\sum_{j=1}^{n} a_{ij} X_j < b_i$ ($i = K + 1$,………. m constraints)
3. $\sum_{j=1}^{n} a_{ij} X_j = b_i$ ($i = m + 1$, ………. v constraints)
4. X_j, $b_i > 0$ (non negativity constraint)

where,

Z = is the objective function to be maximized in the year.

C_j = is the value of j^{th} activity during *kharif* and *rabi* seasons of the year.

X_j = is the unit of j^{th} production activity during *kharif* and *rabi* seasons of the year.

a_{ij} = amount of i^{th} resource required by one unit of j^{th} activity

b_i = supply levels of i^{th} resource or input in the specified

Linear programming was used to develop optimum plans. A total of twenty-four optimum plans were developed for head, middle and tail regions for small and large farms of Somasila Project command area

Head Region-Small farmers

Model - 1: HS1 Plan with existing water supply level

Model - 2: HS2 Optimum plan with 10 percent decrease in water availability

Model - 3: HS3 Optimum plan with 20 percent decrease in water availability

Model - 4: HS4 Optimum plan with 30 percent decrease in water availability

Head Region-Large farmers

Model - 1: HL1 Plan with existing water supply level

Model - 2: HL2 Optimum plan with 10 percent decrease in water availability

Model - 3: HL3 Optimum plan with 20 percent decrease in water availability

Model - 4: HL4 Optimum plan with 30 percent decrease in water availability

Middle Region-Small farmers

Model - 1: MS1 Plan with existing water supply level

Model - 2: MS2 Optimum plan with 10 percent decrease in water availability

Model - 3: MS3 Optimum plan with 20 percent decrease in water availability

Model - 4: MS4 Optimum plan with 30 percent decrease in water availability

Middle Region-Large farmers

Model -1: ML1 Plan with existing water supply level

Model- 2: ML2 Optimum plan with 10 percent decrease in water availability

Model- 3: ML3 Optimum plan with 20 percent decrease in water availability

Model- 4: ML4 Optimum plan with 30 percent decrease in water availability

Tail Region-Small farmers

Model - 1: TS1 Plan with existing water supply level

Model - 2: TS2 Optimum plan with 10 percent decrease in water availability

Model - 3: TS3 Optimum plan with 20 percent decrease in water availability

Model - 4: TS4 Optimum plan with 30 percent decrease in water availability

Tail Region-Large farmers

Model - 1: TL1 Plan with existing water supply level

Model - 2: TL2 Optimum plan with 10 percent decrease in water availability

Model - 3: TL3 Optimum plan with 20 percent decrease in water availability

Model - 4: TL4 Optimum plan with 30 percent decrease in water availability

LINGO 17.0 tool is used to analyze the data. LINGO is a tool that is designed to solve linear, non-linear, quadratic, integer models fast and provides an accurate result (optimization modelling with Lingo-fifth edition).

RESULTS AND DISCUSSION

The objective of the study was to examine the changes in income under different water availability situations. Profit maximization has been assumed as the objective function of the farmers and optimal plans for the small and large farms in the three regions viz., head, middle and tail were developed with the help of linear programming.

Net Farm Returns Under Different Optimum Plans

The prime objective of the study was to explore the possibilities of augmenting net farm returns of farmers from the various activities under varied water availability situations. The net farm returns for small and large farmers of head, middle and tail regions of the command area were presented in Table from 1 to 3.

Small Farmers of Head Region

The small farmers of head region, on an average, realized ₹ 33,187.79 as net farm returns from existing production progrmame. Model HS1 offered scope for augmenting net farm returns to ₹ 50,963.47, an increase of 53.56 per cent over the existing situation. Thus, it is evident that the small farmers can increase their net farm returns by mere reallocation of resource.

Model HS2 (10 per cent reduction in water supply) results suggested the prospects of raising the net farm returns to ₹ 49,957.13 recording a raise of 50.53 per cent over the existing returns.

The net farm returns in model HS3 (20 per cent reduction in water availability) were higher by ₹ 15,404.72 over the existing returns. The results of the optimal plan designed at 30 per cent decrease in the water availability indicated raising of net farm returns from ₹ 33,187.79 in the current plan to ₹ 43,763.25 recording an increase of 31.87 per cent over the existing plan (Table 1).

Large Farmers of Head Region

The net farm returns under optimum model HL_1 (existing water availability) were ₹ 1,07,006 as against the present net farm returns of ₹ 74,307.16 which accounted for 44 per cent increase in income over the existing plan.

The optimum model HL_2 in which water availability was reduced by 10 per cent had pared the way for securing ₹ 1,06,775 as net farm income by the large farmers and exhibited 43.69 per cent increase in income over the current plan.

The optimal model HL_3 which was designed at 20 per cent decrease in water supply enabled the farmers to increase the net farm income by ₹ 32,236.84 (43.38 %) over the existing plan.

Model HL_4 (30 per cent decrease in water availability) suggested the possibilities of raising net farm returns to ₹ 1,01,871, registering an increase of 37.09 per cent over the present level of income.

Small Farmers of Middle Region

The net farm returns under model MS_1 (existing water availability) were ₹ 46,868.55 as against the present net farm returns of ₹ 31,716.76 which accounted for 47.77 per cent increase in income over the existing plan. (Table 3.2).

Model MS_2 (10 per cent decrease in the water availability) indicated opportunities to increase the income from ₹ 31,716.76 in the current plan to ₹ 45,933.67 in MS_2. The net farm returns of model MS_2 were 44.82 per cent higher than the returns in the existing plan.

Planning under 20 per cent decrease in the water availability (Model MS_3) helped the small farmers of middle region to increase the income by ₹ 8,941.45 (28.19 %) over the existing income.

The programming model MS_4 designed at 30 per cent declined in the water availability suggested the possibilities of raising net farm returns to ₹ 34,881.88 registering an increase of 9.98 per cent over the current level of net farm income.

Large Farmers of Middle Region

On an average, the large farmers of middle region realized ₹ 71,489.29 in the existing production plan. Model ML_1 offered scope for augmenting net farm returns of ₹ 99,199.60, an increase of 38.76 per cent over the existing situation (Table 2).

The net farm returns in model ML_2 (10 per cent decrease in water supply) was higher by ₹ 24,914.71 (34.85 %) over the currently practiced plan.

The results of model ML_3 indicated the possibilities of raising the net farm returns to ₹ 87,284 recording a raise of 22.09 per cent over the existing income.

Model ML_4 (30 per cent reduction in the water availability) offered scope to raise net farm income by ₹ 5,383.74 (7.53%) over the current level of income.

Small Farmers of Tail Region

The net farm returns under model TS_1 (existing water availability) were ₹ 41,728.96 as against present net farm returns of ₹ 28,054.68 which accounted for 48.74 per cent increase in income over the existing plan. This indicates the scope to increase their net farm returns by mere reorganization of resources.

Model TS_2 (10 per cent reduction in water supply) resulted an increase in net farm returns by ₹ 13,351.54 registering an increase of 47.59 per cent over the existing plan (Table 2).

The programming model TS_3 (20 per cent reduction in water availability) helped 10 realize ₹ 39,820.15 as net farm income, recording 41.94 per cent of increase over the existing returns.

Model TL_4 (30 per cent reduction in water availability) indicated the possibilities of raising the net farm returns to ₹ 35,229.73 recording an increase of 25.58 per cent over the existing level of net farm returns.

Large Farmers of Tail Region

The net farm returns under model TL_1 were ₹ 70,713.59 as against the present net farm returns of ₹ 49,526.29. The increase in the net farm returns in model TL_1 was 42.78 per cent over the existing situation.

Model TL_2 (10 per cent decrease in water availability) offered scope of raising net farm returns by ₹ 18,108.76 (36.56 %) over the existing plan.

The large farmers of tail region realized ₹ 64,556.52 through the reorganization of resources at 20 per cent declined in water availability (Model TL_3) recording a raise of 30.35 per cent over the present level of income.

Optimal plan TL_4 enabled the farmers to increase the net farm returns by ₹ 8,371.41 (16.90 per cent) over the income obtained from current crop mix.

The analysis of net farm returns indicated, there is an ample scope for enhancing the net farm returns on the small and large farms of head, middle and tail regions through mere reorganization of farm resources. However, the potentiality of increasing the returns was more on the farms of head region compared to middle and tail regions under different water availability situations.

These findings are in conformity with the findings of Singh *et al.* (1972), Subbarayan and Singh (1989), Gajanana and Sharma (1990), Sharma *et al.* (1996), Tilekar and Nimbalkar (2000), Shareef and Murthy (2001), Kiresur *et al.* (2004).

Impact of Irrigation Water on Net Farm Income

The optimum models were developed with 10, 20 and 30 per cent decrease in the availability of water to examine its influence on cropping pattern and income levels. The details of the impact of irrigation water on net farm returns on the farms of head, middle and tail regions are presented in Table 1 to 3.

Head Region

The net farm returns indicated by models HS1and HL_1 were ₹ 50,963.47 and ₹ 1,07,006 for the small and large farmers of head region respectively under existing water availability. When water availability was reduced by 10 per cent over the existing water availability, the net farm returns decreased to ₹ 49,957.13 on small farms and ₹ 1,06,775.00 on large farms. The decrease of ₹ 1006.34 (1.97%) and ₹ 231 (0.22%) on the small and large farms respectively could be attributed to reduction of water supply by 10 per cent. The net farm returns of small and large farmers in model HS3 and HL_3 were declined to ₹ 48,592.51 and ₹ 1,06,544 respectively when the irrigation water supply reduced by 20 per cent. The reduction in net farm returns were ₹ 2,370.96 (4.65%) and ₹ 462 (0.43%) on small and large farms

Table 1: Impact of irrigation water on net farm returns of small and large farmers - Head regions (in ₹)

Category / model	Existing plan (E-Plan)	Model - H_1 (Change over E-Plan)	Model - H_2 (Change over E-Plan)	Change over Model – H_1	Model -H_3 (Change over E-Plan)	Change over Model – H_1	Change over Model – H_2	Model -H_4 (Change over E-Plan)	Change over Model - H_1	Change over Model -H_2	Change over Model - H_3
Small farmers (S)	33187.79	50963.47 (53.56)	49957.13 (50.53)	-1006.34 (1.97)	48592.51 (46.42)	-2370.96 (4.65)	-1364.62 (2.73)	43763.25 (31.87)	-7200.22 (14.13)	-6193.88 (12.39)	-4829.26 (9.94)
Large farmers (L)	74307.16	107006.00 (44.00)	106775.00 (43.69)	-231.00 (0.22)	106544.00 (43.38)	-462.00 (0.43)	-231.00 (0.22)	101871.00 (37.09)	-5135.00 (4.79)	-4904.00 (4.59)	-4673.00 (4.39)

Figures in the parentheses indicate the percentages.

Table 2: Impact of irrigation water on net farm returns of small and large farmers – middle regions (in ₹)

Category / model	Existing plan (E-Plan)	Model - M_1 (Change over E-Plan)	Model – M_2 (Change over E-Plan)	Change over Model–M_1	Model – M_3 (Change over E-Plan)	Change over Model–M_1	Change over Mode –M_2	Model – M_4 (Change over E-Plan)	Change over Model–M_1	Change over Model –M_2	Change over Model – M_3
Small farmers (S)	31716.76	46868.55 (47.77)	45933.67 (44.82)	-934.88 (1.99)	40658.21 (28.19)	-6210.34 (13.25)	-5275.46 (11.48)	34881.88 (9.98)	-11986.67 (25.58)	-11051.79 (24.06)	-5776.33 (14.21)
Large farmers (L)	71489.29	99199.60 (38.76)	96404.00 (34.85)	-2795.60 (2.82)	87284.00 (22.09)	-11915.60 (12.01)	-9120.00 (9.46)	76873.03 (7.53)	-22326.57 (22.51)	-19530.97 (20.26)	-10410.97 (11.93)

Figures in the parentheses indicate the percentages.

Table 3: Impact of irrigation water on net farm returns of small and large farmers – Tail regions (in ₹)

Category / model	Existing plan (E-Plan)	Model - T_1 (Change over E-Plan)	Model - T_2 (Change over E-Plan)	Change over Model - T_1	Model - T_3 (Change over E-Plan)	Change over Model - T_1	Change over Model - T_2	Model - T_4 (Change over E-Plan)	Change over Model - T_1	Change over Model - T_2	Change over Model - T_3
Small farmers (S)	28054.68	41728.96 (48.74)	41406.22 (47.59)	-322.74 (0.77)	39820.15 (41.94)	-1908.81 (4.57)	-1586.07 (3.83)	35229.73 (25.58)	-6499.23 (15.57)	-6176.49 (14.92)	-4590.42 (11.53)
Large farmers (L)	49526.29	70713.59 (42.78)	67635.05 (36.56)	-3078.54 (4.35)	64556.52 (30.35)	-6157.07 (8.71)	-3078.53 (4.55)	57897.7 (16.90)	-12815.89 (18.12)	-9737.35 (14.39)	-6658.82 (10.31)

Figures in the parentheses indicate the percentages.

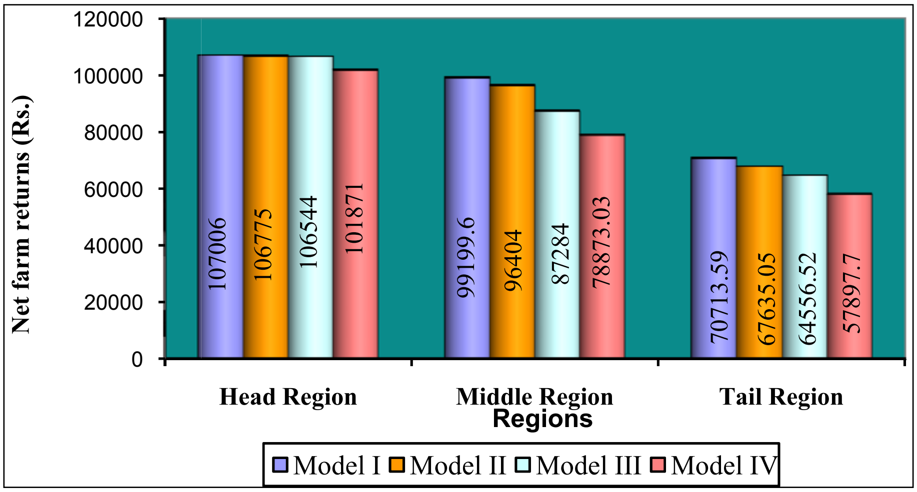

Fig. 1: Impact of irrigation water on net farm income under different optimum plans - Large farmers

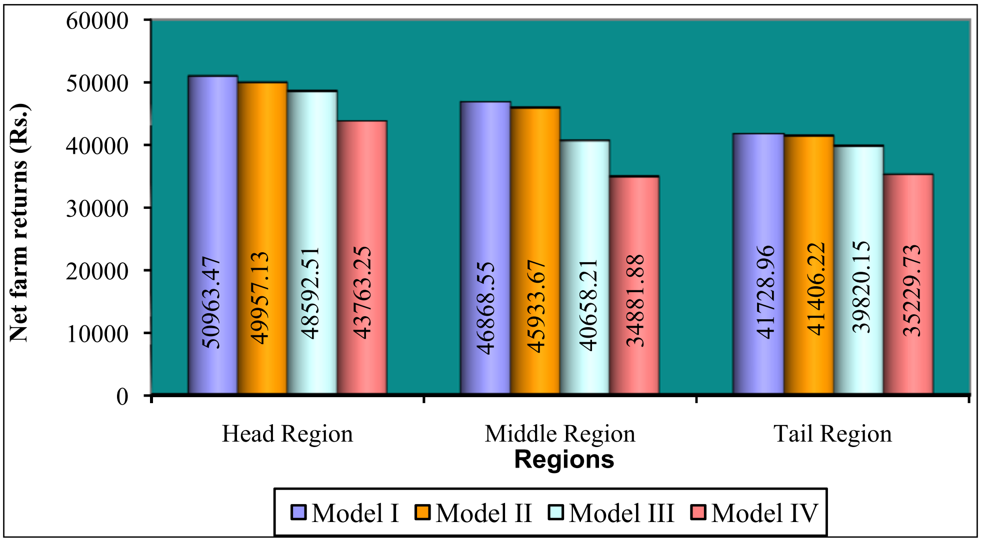

Fig. 2: Impact of irrigation water on net farm income under different optimum plans - Small farmers

respectively over the optimization models with existing water availability (Table 1).

The optimization models of small and large farms with 30 per cent decline in the water availability indicated the possibilities of realizing a net farm income of ₹ 43,763.25 and ₹ 1,01,871.00 respectively indicating a decline of 14.13 per cent and 4.70 per cent on the above said categories of farms over the optimal plans with existing water availability.

Middle Region

A comparison of results of model M1, M2, M3 and M4 indicates the impact of irrigation water, when the availability of water decreased by 10, 20 and 30 per cent respectively. The net farm returns indicated by models MS_1 and ML_1 were ₹ 46,868.55 and ₹ 99,199.60 for small and large farmers of middle region respectively. When the water availability was restricted to the existing level. When the water availability was reduced by 10, 20 and 30 per cent the net farm returns reduced to ₹ 45,933.67, ₹ 40,658.21 and ₹ 34,881.88 on small farms and ₹ 96,404, ₹ 87,284 and ₹ 76,873.03 on large farms respectively.

The reduction of net farm returns over the optimal plans with existing water availability by ₹ 934.88 (1.99%), ₹ 6,210.34 (13.25%), and ₹ 11,986.67 (25.58%) on the small farms and ₹ 2,795.60 (2.82%), ₹ 11,915.60 (12.01%), ₹ 22,326.57 (22.51%) on the large farms could be attributed to the scarcity of water resource and the consequential changes in crop mix (Table 2).

Tail Region

The impact of variations in the water availability can be assessed by comparing the models developed with existing water availability (Model TS_1 and TL_1) and reduction in the irrigation water supply by 10, 20 and 30 per cent (TS_2, TS_3 and TS_4 and TL_2, TL_3 and TL_4). The net farm returns of small and large farms of tail region with existing water availability were ₹ 41,728.96 and ₹ 70,713.59 respectively. On the other hand, if water availability was reduced by 10, 20 and 30 per cent, the small farmers were able to realize ₹ 41,406.22, ₹ 39,820.15 and ₹ 35,229.73 while the large farmers ₹ 67,635.05, ₹ 64,556.52 and ₹ 57,897.70 respectively. The proportionate decline in the net farm returns was 0.77, 4.57 and 15.57 per cent on the small farms and 4.35, 8.71, 18.12 per cent on large farms in the same order over the optimal plans with existing water availability (Table 3).

From the above analysis, it may be inferred that water availability played a key role in realizing income in all the regions. There is a direct relationship between income and the availability of irrigation water. It is also evident that the decline in the net farm returns was more pronounced on both the categories of farms of the three regions when water availability was reduced by 30 per cent. These findings are in agreement with the findings of Shareef and Murthy (2001).

CONCLUSION

The present study is an attempt to analyse the possibilities and prospects of increasing the net farm income by better resource allocation through optimum enterprise system. There is greater scope for increasing the net farm returns and resources through systematic farm planning under the existing water supply and resource base on the farms of the three regions. The sensitivity analysis with reduced availability of water by 10, 20 and 30 per cent level revealed that the farmers income could be increased over the existing plan if the normative plans are adopted. The optimum plans developed at 30 per cent reduction in water availability indicated substantial decrease in net farm income. The scope for water resource development and use is encouraging as revealed through the MVP for irrigation water. Farm planning as an extension tool could be popularized by the extension agencies to convince the farmers on the need for changing the crop mix in the command area which led to increase in the income levels as observed in the optimum plans even at lower water availability conditions over the existing production programme.

REFERENCES

Gajanana, T.M. and Sharma, B.M. 1990. Income and employment prospects of drought prone farmers - Role of credit and technology. *Agril. Situation in India*, **45**(5): 307-312.

Kiresur, V.R., Gaddi, G. M., Gummagolnath, K.C., Wadear, R.R. and Kulkarni, V.S. 2004 Optimum plans for sustainable farming systems in Northern Eastern Dry zone in Karnataka-A linear programming approach. *The Bihar J. Agril. Market.*, **12**(1): 16-27.

Nagaraja, G.N. and Venkataram, J.V. 1983. An optimum cropping pattern and its impact of net farm returns in Daddaballapur *taluk*, Bangalore district of Karnataka – An application of linear programming technique. *Agril. Banker*, **6**(2): 16 -18.

Parasurama Reddy, G., Venkatram, J.V. and Nagaraja, G.N. 1989. An optimum resource use pattern and credit requirement for the beneficiaries of Upper Krishna Project Command Area of Karnataka. *Financing Agric.*, **21**(4): 25.

Selvarajan, S. and Subramanian, S.R. 1981. Economic impact of resource use optimization and water augmentation in farms of Parambikulam Aliyar Project region. *Indian J. Agril. Econ.*, **36**(1): 89-101.

Shareef, S.M. and Krishna Murthy, S. 2001. Optimum plans for increasing income, employment and water use at farm level in three regions of K.C Canal Irrigation system in Andhra Pradesh. *Agril. Situation in India*, **57**(11): 603-610.

Sharma, B.M., Puranchand, and Vasisht, A.K. 1996. Role of diversification in eradication of farm poverty- A case study of Alwar district of Rajasthan State. *Indian J. Agril. Econ.*, **57**(4): 707–708.

Singh, R.D., Varma, R.K. and Singh, L.R. 1972. Production possibilities and resources use pattern on small farmers – A comprehensive study in three regions of Uttar Pradesh. *Indian J. Agril. Econ.*, **27**(4): 126-136.

Subbarayan, M. and Singh, I. 1989. Optimal use of irrigation water resource in the eastern Yamuna canal command in western Uttar Pradesh. *Indian J. Agril. Econ.*, **44**(3): 267.

Tilekar, S.N. and Nimbalkar, C.A. 2000. Optimization of farm income in and outside Mula Irrigation command area; use of Linear Programming Technique, *J. Maharashtra Agril. Univ.*, **25**(3): 284-288.