The Pharma Innovation Journal 2023; 12(5): 3976-3981

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(5): 3976-3981
© 2023 TPI
www.thepharmajournal.com
Received: 05-01-2023
Accepted: 10-03-2023

Dr. Ch. Srilatha
Assistant Professor, School of Agribusiness Management, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad, India

Corresponding Author:
Dr. Ch. Srilatha
Assistant Professor, School of Agribusiness Management, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad, India

Impact of irrigation water on employment in three regions of Somasila project in Andhra Pradesh: A linear programming approach

Dr. Ch Srilatha

Abstract

The present study is an effort to analyze the possibilities and prospects of increasing the employment and 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 progressive command area of Andhra Pradesh. A multistage 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 three villages were selected and that total number of villages chosen were 12. The number of farmers selected from each village was ten and that total number of farmers selected for purpose of present study was 120. Linear programming was used to develop optimum plans. A total of twenty-four optimum plans were developed for head, middle and tail regions and farms of Somasila Project command area. The results of the study shown 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 employment and net farm returns of both the categories of farmers in the study area. However, the effect of irrigation water on employment, net farm income and other inputs was constantly decreased by decreasing water availability. It is also evident that the decline in the employment, net farm returns and use of other inputs were more pronounced on both the categories of farms of the three regions when water availability was reduced by 30 per cent.

Keywords: Optimum plans, employment, rational resource allocation, linear programming model

Introduction

Agriculture plays a vital role in India's economy. 54.6 per cent of the total workforce is engaged in agricultural and allied sector activities (Census, 2011) and accounts for 17.8 per cent of the country's Gross Value Added (GVA) for the year 2019-20 (Annual Report, 2021-22, Department of Agriculture, Cooperation & Farmers welfare, Ministry of Agriculture& Farmers welfare, GOI). Share of agricultural exports as a percentage of agricultural GDP has decreased from 9.9 per cent in 2018-19 to 8.3 per cent in 2019-20. Having achieved laudable success in agricultural production in the last 50 years, India has transformed herself from a food deficit to a food surplus country. Still there are many challenges, which Indian agriculture is facing in the fast-changing market economy. Relating to the natural resources and production base, water has emerged as the most crucial factor for sustaining the agricultural sector in the coming years.

India holds 17.5 per cent of the world's population and nearly 30 per cent of the cattle with only 2.4 per cent of the land area and 4 per cent of water resources. Even if the full irrigation potential is exploited, about 50 per cent of the country's cultivated area will remain unirrigated, particularly with current level of irrigation efficiency.

The population increase coupled with improved purchasing power associated with economic growth would enhance not only the demand for cereal foods, but also the demand for other products. According to recent estimates, the country will need about 310.8 Million metric tonnes of food grains, 170.4 Million metric tonnes of milk, 192.0 Million metric tonnes of vegetables, 103.0 Million metric tonnes of fruits, 11.1 Million metric tonnes of fish and 21.3 Million metric tonnes of edible oils to provide adequate nutrition to 1.515 billion people by 2030 AD (Kumar. P *et al*., 2016) [9]. The expanding demand for agriculture commodities together with limited availability of farm resources (water and labour which are highly transferred to nonagricultural sectors) needs a careful exploitation of production possibilities and ways for increasing the efficiency of resources on various sizes of farm.

The rational use of resources on farm can be achieved by determining scientific optimal enterprise mix resulting in increased farm returns and employment. 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 and employment prospects of farmers through optimum reorganization of resources.

Materials and Methods

Somasila project constructed across the river Pennar was selected purposively for the present study, as it is one of the major command areas of Andhra Pradesh. The entire command area is divided into three regions *viz.*, head, middle and tail region. 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 the three regions of command area were obtained from the village officials. The categorization of farmers into small and large farms was done on the basis of land holdings as per the criterion adopted by IRDP. In this classification, two acres of dry land was considered equal to one acre of wet land in accordance with income generation capacity of dry and wet lands. The farmers with two hectares and less were considered as small, while the farmers having more than 2 hectares were grouped as large farmers. From the list of farmers in each village, five each from small and large farmers were selected at random. Thus, number of farmers selected from each village was ten and that total number of farmers selected for the purpose of present study was 120.

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.

Maximise

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

j= 1 to n activities

Subject to following constraints

1. $\sum_{j=1}^{n} a_{ij} X_j \geq b_i$ (i = 1, ……….K constraints)

2. $\sum_{j=1}^{n} a_{ij} X_j \leq b_i$ (i = K+1,………. m constraints)

3. $\sum_{j=1}^{n} a_{ij} X_j = b_i$ (i = m+1, ………. v constraints)

4. X_j , $b_i \geq 0$ (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 units.

Objective Function

The objective function for the model in this study was to maximize the employment and annual net farm returns from crop enterprises subject to the resource constraints specified in the model.

In this model the value of objective function (the optimum solution) which was to be maximized included the sum of the year's net cash flow. The final cash flow into the objective function was the result of changes arising from production, marketing, borrowing and debt management during the year. In interpreting the results of the model, the value of the objective function was adjusted by subtracting owned funds.

Variations of the Model

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.

Inadequate water supply was experienced by the farmers in number of years, the reduction in water supply ranging from 10 to 30 per cent. So, sensitivity analysis was also done with varying water levels representing three abnormal situations to study the impact on cropping pattern, employment, income level and the use of inputs and input service.

The model was first run with the existing water supply level (Model 1). Later with 10 per cent decrease in water supply (Model 2), 20 per cent decrease in water supply (Model 3) and 30 per cent decrease in water supply (Model 4) were assumed and corresponding models were solved to examine the effect of irrigation water on cropping pattern, in come, employment and resource use pattern.

Results and Discussion

The present study has an objective to examine the changes in employment and income under different water availability situations. The results obtained in this study and inferences drawn in the discussion refer to an average farm situation of small and large farmers. Linear programming technique was employed to develop twenty four optimal plans for farmers of the Somasila Project command area of Nellore district, Andhra Pradesh.

Impact of water availability on employment

The impact of reduction in irrigation water on the employment of input services *viz.*, men, women, bullock labour and tractor power can be examined by comparing the optimum models HS1, HL_1, MS_1, ML_1, TS_1 and TL_1 with the optimum models designed at 10, 20 and 30 per cent reduction in irrigation water supply over the existing plan.

Head region

It may be observed from the Table 3.1 that the use of input services declined with reduction in the water availability. In the case of small farms, the employment of men, women, bullock labour and tractor power declined from 92.06 man days, 140.14 woman days, 14.39 bullock pair days and 11.02 hours of tractor services in optimum model HS1 developed with existing water availability to 69.64 man days (24.35%), 109.70 woman days (21.72%), 10.92 bullock pair days (24.11%) and 10.10 hours of tractor service (8.35%) in the programming model developed with 30 per cent reduction in the water availability (HS4).

On large farms, the decline in the labour use was maximum in optimal plan HL_4. The annual employment of men, women, bullock labour and tractor service was reduced by 63.85 man days, 72.59 woman days, 6.04 bullock pair days and 2.25 hours of tractor power in HL_4 over HL_1.

Middle Region

The labour use on the small farms was reduced by 22.25 man days (23.75%), 29.17 woman days (19.68%), 4.56 bullock pair days (32.76%) and 1.87 hours of tractor service (15.79%) in MS_4 over MS_1.

On large farms, though there was reduction in the labour use in all the models M2, M3 and M4 compared with the model M1 but it was maximum in M4. Labour employment was declined to the extent of 53.99 man days, 26.27 woman days, 7.47 bullock pair days and 3.39 hours of tractor service (Table 3.2).

Tail Region

Impact of irrigation water on employment of small and large farm is presented in Table 3.3.

On small farms of tail region, use of men, women, bullock labour and tractor service reduced from 73.61 man days, 154.94 woman days, 13.19 bullock pair days and 10.66 hours of tractor service in optimum model TS_1 to 58.94 man days, 137.51 woman days, 9.28 bullock pair days and 8.63 hours of tractor service in TS_4.

On large farms, annual employment of input services was declined by 33.81 man days (19.21%), 82.13 woman days (22.65%), 7.39 bullock pair days (36.33%) and 6.33 (20.04%) hours of tractor service in Model TL_4 over model TL_1.

Shadow Prices

This unit presents the shadow prices of selected resources in optimum solution of different models. Shadow prices refer to the marginal value products of the resources. They indicate quantum of change in the net farm returns due to a unit change of that resource ceteris paribus. They are of interest to the decision makers and planners because they indicate the most profitable resources to alter and also the maximum amount of each resource that can be used in a particular production process. The shadow prices with positive sign mean that a unit increase in the quantity of resource used would increase the objective function by the amount shown.

Shadow prices would be zero when a resource is not completely utilized because there is no return added for the marginal use of resource, all other conditions remaining the same. However, the marginal value product of resource change if one or more of other conditions change. The shadow prices of selected resources on the small and large farms of head, middle and tail regions are presented in Table from 3.4 to 3.9.

Head Region

The optimization models of small and large farms (except HS4) showed shadow prices for both *kharif* and *rabi* irrigated land. This reflected complete use of land resource.

The results of optimal plans designed at 30 per cent reduction in water availability indicated lower shadow prices for *kharif* and *rabi* irrigated land as compared to the shadow prices in other optimal plans. This clearly reveals that the profitability of farm business could be increased if the farmers are provided with adequate irrigation of water (Table 3.4 and 3.5).

The programming models designed at existing water availability and 10, 20 and 30 per cent shortage of water supply indicated shadow prices for resource services (men, women, bullock labour and tractor service) and irrigation water on both the categories of farms in *kharif* and *rabi* (except men and bullock labour in all the normative plans of small farms).

The marginal value productivity of irrigation water was higher during *kharif* compared to *rabi* season. The shadow prices of irrigation water in *kharif* and *rabi* were the highest in the optimum plan developed with 30 per cent decrease in water availability. The shadow price of irrigation water were higher on small farms compared to large farms and thus reflected higher profitability among small farms for each additional hectare centimeter of irrigation water if it could be made available. It can be inferred that the scarcity of irrigation water was more on the small farms.

Middle Region

The Table 3.6 and 3.7 showed that, all the optimum models of large farms indicated shadow prices for man labour, woman labour, bullock labour, tractor services in both the seasons. On the contrary, the shadow prices of man labour, bullock labour in *kharif* and *rabi* seasons on the small farms were zero. This indicates that an additional employment of these resources would not add any more to the net farm returns. Except MS_4, all other programming models indicated shadow prices for land resource. The normative plan MS_4 showed zero shadow price for *kharif* irrigated land. The plausible reason for the underutilization of *kharif* land was shortage of irrigation water.

The profitability of irrigation water in *kharif* and *rabi* was indicated by all the optimal plans.

Tail Region

From the table 3.8 and 3.9, it is observed that the shadow prices were indicated by all the optimum models for resources services like man labour, woman labour, bullock labour, tractor services on small and large farms in both the seasons except man labour, and bullock labour on the small farms. Bullock labour and man labour were considered to be surplus in both the seasons on the small farms as reflected by zero shadow prices in the optimum models. The profitability of additional unit of irrigation was indicated by all the models (except TS_4 in kharif and TL_4 in kharif and rabi).

Table 1: Impact of irrigation water on labour employment of small and large farmers – Head region

Particulars	Model-T_1	Model-T_2	Change over Model T_1	Model-T_3	Change over Model T_1	Change over Model T_2	Model-T_4	Change over Model T_1	Change over Model T_2	Change over Model T_3
Small farmers										
Total mandays	92.06	84.48	-7.58 (8.23)	78.29	-13.77 (14.87)	-6.19 (7.33)	69.64	-22.42 (24.35)	-14.84 (17.57)	-8.65 (11.05)
Total woman days	140.14	132.84	-7.30 (5.21)	117.83	-22.31 (15.92)	-15.01 (11.29)	109.70	-30.44 (21.72)	-23.14 (17.42)	-8.13 (6.89)
Total bullock days	14.39	13.69	-0.70 (4.86)	12.15	-2.24 (15.57)	-1.54 (11.25)	10.92	-3.47 (24.11)	-2.77 (20.23)	-1.23 (10.12)
Total tractor hours	11.02	10.51	-0.51 (4.63)	10.40	-0.62 (5.63)	-0.11 (1.05)	10.10	-0.92 (8.35)	-0.41 (3.90)	-0.30 (2.88)
Large farmers										
Total mandays	246.33	227.15	-19.18 (7.79)	207.98	-38.35 (15.57)	-19.17 (8.44)	182.48	-63.85 (25.92)	-44.67 (19.67)	-25.50 (12.26)
Total woman days	368.29	353.62	-14.67 (3.98)	338.93	-29.36 (7.97)	-14.69 (4.15)	295.70	-72.59 (19.71)	-57.92 (16.38)	-43.23 (12.75)
Total bullock days	28.29	28.72	0.43 (1.52)	29.16	0.87 (3.07)	0.44 (1.53)	22.25	-6.04 (21.35)	-6.47 (22.53)	-6.91 (23.69)
Total tractor hours	35.01	32.79	-2.22 (6.34)	30.57	-4.53 (12.94)	-2.22 (6.77)	32.76	-2.25 (6.41)	-0.03 (0.09)	2.19 (7.16)

Figures in the parentheses indicate the percentages

Table 2: Impact of irrigation water on labour employment of small and large farmers – Middle Region

Particulars	Model-T_1	Model-T_2	Change over Model T_1	Model-T_3	Change over Model T_1	Change over Model T_2	Model-T_4	Change over Model T_1	Change over Model T_2	Change over Model T_3
Small farmers										
Total mandays	93.59	94.82	1.23 (1.31)	79.05	-14.54 (15.53)	-15.77 (16.63)	71.34	-22.25 (23.77)	-23.48 (24.76)	-7.71 (9.69)
Total woman days	148.23	134.24	-13.99 (9.44)	132.24	-15.99 (10.79)	-2.00 (1.49)	119.06	-29.17 (19.68)	-15.18 (11.31)	-13.18 (9.97)
Total bullock days	13.92	10.62	-3.3 (23.71)	10.45	-3.47 (24.93)	-0.17 (1.60)	9.36	-4.56 (32.76)	-1.26 (11.86)	-1.09 (10.43)
Total tractor hours	11.84	11.20	-0.64 (5.41)	11.42	-0.42 (3.55)	0.22 (1.96)	9.97	-1.87 (15.79)	-1.23 (10.98)	-1.454 (12.69)
Large farmers										
Total mandays	224.99	211.91	-13.08 (5.81)	193.61	-31.38 (13.95)	-18.30 (8.64)	171.00	-53.99 (23.99)	-40.91 (19.31)	-22.61 (11.68)
Total woman days	336.69	310.90	-25.79 (7.66)	300.05	-36.64 (10.88)	-10.85 (3.49)	310.42	-26.27 (7.80)	-0.48 (0.15)	9.92 (3.30)
Total bullock days	21.93	19.37	-2.56 (11.67)	15.34	-6.59 (30.05)	-4.03 (20.81)	14.46	-7.47 (34.06)	-4.91 (25.35)	-0.88 (5.74)
Total tractor hours	25.83	25.96	0.13 (0.50)	27.26	1.43 (5.54)	1.30 (5.00)	29.22	3.39 (13.12)	3.26 (12.56)	1.96 (7.19)

Figures in the parentheses indicate the percentages

Table 3: Impact of irrigation water on total labour employment of small and large farmers – Tail Region

Particulars	Model-T_1	Model-T_2	Change over Model T_1	Model-T_3	Change over Model T_1	Change over Model T_2	Model-T_4	Change over Model T_1	Change over Model T_2	Change over Model T_3
Small farmers										
Total mandays	73.61	71.88	-1.73 (2.35)	72.24	-1.37 (1.86)	0.36 (0.50)	58.94	-14.67 (19.92)	-12.94) (18.00	-13.30 (18.41)
Total woman days	154.94	152.08	-2.86 (1.85)	142.04	-12.90 (8.33)	-10.04 (6.60)	137.51	-17.23 (11.25)	-14.57 (9.58)	-4.53 (3.19)
Total bullock days	13.19	13.02	-0.17 (1.29)	11.13	-2.06 (15.62)	-1.89 (14.52)	9.28	-3.91 (29.64)	-3.74 (28.73)	-1.85 (16.62)
Total tractor hours	10.66	10.50	-0.16 (1.50)	9.46	-1.20 (11.26)	-1.04 (9.90)	8.63	-2.03 (19.04)	-1.87 (17.81)	-0.83 (8.77)
Large farmers										
Total mandays	176.01	165.35	-10.66 (6.06)	154.69	-21.32 (12.11)	-10.66 (6.45)	142.20	-33.81 (19.21)	-23.15 (14.00)	-12.49 (8.07)
Total woman days	362.65	339.92	-22.73 (6.27)	317.19	-45.46 (12.54)	-22.73 (6.69)	280.52	-82.13 (22.65)	-59.40 (17.47)	-36.67 (11.56)
Total bullock days	20.34	18.16	-2.18 (10.72)	15.98	-4.36 (21.44)	-2.18 (12.00)	12.95	-7.39 (36.33)	-5.21 (28.69)	-3.03 (18.96)
Total tractor hours	31.59	30.06	-1.53 (4.84)	28.53	-3.06 (9.69)	-1.53 (5.09)	25.26	-6.33 (20.04)	-4.80 (15.97)	-3.27 (11.46)

Figures in the parentheses indicate the percentages

Table 4: Shadow prices of selected resources on small farms under different optimum models - Head Region (in Rs.)

Land Resource	Model – HS_1	Model – HS_2	Model – HS_3	Model – HS_4
Kharif irrigated land	12064.12	12064.12	10231.18	-
Rabi irrigated land	14366.20	14366.20	13560.22	10686.21
***Kharif* input services and inputs**				
Man	-	-	-	-
Woman	26.00	26.00	-	-
Bullock	-	-	-	-
Tractor	260.00	260.00	260.00	260.00
Irrigation water	79.14	79.14	144.14	371.50
***Rabi* input services and inputs**				
Man	-	-	-	-
Woman	25.00	25.00	25.00	-
Bullock	-	-	-	-
Tractor	250.00	250.00	250.00	250.00
Irrigation water	32.67	32.67	64.91	227.87

Table 5: Shadow prices of selected resources on large farms under different optimum models - Head Region (in Rs.)

Land Resource	Model – HL_1	Model – HL_2	Model – HL_3	Model – HL_4
Kharif irrigated land	19131.12	19131.12	19131.12	4875.38
Rabi irrigated land	13588.00	13588.00	13588.00	8519.29
***Kharif* input services and inputs**				
Man	46.80	46.80	46.80	46.80
Woman	26.00	26.00	26.00	26.00
Bullock	124.00	124.80	124.00	124.00
Tractor	260.00	260.00	260.00	260.00
Irrigation water	8.98	8.98	8.98	325.78
***Rabi* input services and inputs**				
Man	45.00	45.00	45.00	45.00
Woman	25.00	25.00	25.00	25.00
Bullock	120.00	120.00	120.00	120.00
Tractor	250.00	250.00	250.00	250.00
Irrigation water	1.48	1.48	1.48	204.23

Table 6: Shadow prices of selected resources on small farms under different optimum models - Middle Region (in Rs.)

Land Resource	Model – MS_1	Model – MS_2	Model – MS_3	Model – MS_4
Kharif irrigated land	16345.93	5261.12	1193.29	--
Rabi irrigated land	16498.88	8068.33	6621.99	5910.21
***Kharif* input services and inputs**				
Man	-	-	-	-
Woman	31.20	31.20	31.20	31.20
Bullock	-	-	-	-
Tractor	260.00	260.00	260.00	260.00
Irrigation water	33.10	279.43	369.83	396.34
***Rabi* input services and inputs**				
Man	-	-	-	-
Woman	30.00	30.00	30.00	30.00
Bullock	-	-	-	-
Tractor	250.00	250.00	250.00	250.00
Irrigation water	1.09	188.66	246.52	274.99

Table 7: Shadow prices of selected resources on large farms under different optimum models - Middle Region (in Rs.)

Land Resource	Model – ML_1	Model – ML_2	Model – ML_3	Model – ML_4
Kharif irrigated land	17674.96	9969.32	4106.40	4106.40
Rabi irrigated land	8972.49	5322.44	3237.85	3237.85
***Kharif* input services and inputs**				
Man	46.80	46.80	46.80	46.80
Woman	31.20	31.20	31.20	31.20
Bullock	156.00	156.00	156.00	156.00
Tractor	260.00	260.00	260.00	260.00
Irrigation water	-	171.23	301.52	301.52
***Rabi* input services and inputs**				
Man	45.00	45.00	45.00	45.00
Woman	30.00	30.00	30.00	30.00
Bullock	150.00	150.00	150.00	150.00
Tractor	250.00	250.00	250.00	250.00
Irrigation water	74.76	190.42	273.81	273.81

Table 8: Shadow prices of selected resources on small farms under different optimum models - Tail Region (in Rs.)

Land Resource	Model – TS_1	Model – TS_2	Model – TS_3	Model – TS_4
Kharif irrigated land	20950.64	20950.64	14190.81	--
Rabi irrigated land	13907.38	13907.38	11503.89	6458.26
Kharif input services and inputs				
Man	-	-	-	-
Woman	31.20	31.20	31.20	31.20
Bullock	-	-	-	-
Tractor	312.00	312.00	312.00	312.00
Irrigation water	-	-	150.22	465.57
Rabi input services and inputs				
Man	-	-	-	-
Woman	30.00	30.00	30.00	30.00
Bullock	-	-	-	-
Tractor	300.00	300.00	300.00	300.00
Irrigation water	46.10	46.10	142.24	344.07

Table 9: Shadow prices of selected resources on large farms under different optimum models - Tail Region

Land Resource	Model – TL_1	Model – TL_2	Model – TL_3	Model – TL_4
Kharif irrigated land	8559.61	8559.61	8559.61	--
Rabi irrigated land	10086.67	10086.67	10086.67	--
***Kharif* input services and inputs**				
Man	52.00	52.00	52.00	52.00
Woman	31.20	31.20	31.20	31.20
Bullock	156.00	156.00	156.00	156.00
Tractor	312.00	312.00	312.00	312.00
Irrigation water	37.51	37.51	37.51	227.12
***Rabi* input services and inputs**				
Man	50.00	50.00	50.00	50.00
Woman	30.00	30.00	30.00	30.00
Bullock	150.00	150.00	150.00	150.00
Tractor	300.00	300.00	300.00	300.00
Irrigation water	171.13	171.13	171.13	574.60

Conclusion

From the above analysis, it is clear that the shortage of irrigation water resulted in the reduction of employment of men, women, bullock labour and tractor power. This might be due to the allocation of large proportion of land resource for sunflower, groundnut and greengram that required less irrigation water and labour resource in the optimal plans. Further, it is observed that the labour employment was minimum in the optimum models designed at 30 per cent reduction in the water availability. The optimum plans developed at 30 per cent reduction in water availability indicated substantial decrease in net farm income and labour employment.

Acknowledgments

I extend my sincere heartfelt thanks to my advisor for giving me proper guidance throughout the course of study. I gratefully acknowledge the project preparation cell, Somasila Project circle, Nellore for providing all necessary details for the present study. I also thank the farmers for their co-operation during interview/ data collection.

References

1. Anjum SA, Akbar N, Khan I, Ashraf U, Shakoor A, Saleem N, *et al.* Application of linear programming model to assess the optimum cropping pattern for mixed cropping zone of semi-arid area. Pakistan Journal of Science. 2018;70(4):311-316.
2. Annual Report. Department of Agriculture, Cooperation & Farmers welfare, Ministry of Agriculture& Farmers welfare, GOI; c2021-22.
3. Basumatary UR, Mitra DK. A study on optimal land allocation through fuzzy multi-objective linear programming for agriculture production planning in Kokrajhar district, BTAD, Assam, India. International Journal of Applied Engineering Research. 2000;15(1):94-100.
4. Babatunde RO, Olarunsanya EO, Orebiyi JS, Falola A. Optimal farm plan in sweet potato cropping systems: the case of Offa and Oyun local government areas of Kwara state, north-central Nigeria. Agricultural Journal. 2007;2(2):285-289.
5. Bhatia M, Rana A. A mathematical approach to optimize crop allocation - A linear programming model. International Journal of Design & Nature and Eco dynamics. 2000;15(2):245-252.
6. Das S, Rawat S, Joshi S. A linear programming approach to optimizing organization transportation system. International Journal on Emerging Technologies. (Special Issue NCETST-2017). 2017;8(1):535-541.
7. https://iasscore.in/data-story/irrigation-in-india. Data story: Irrigation in India, 14 March, 2022.
8. Etedali HR, Ahmadaali K, Liaghat A, Parsinejad M, Tavakkoli AR, Ababaei B. Optimum water allocation between irrigated and rainfed lands in. different climatic conditions. Biological Forum – An International Journal 2015;7(1):1556-1567.
9. Kumar P, Joshi PK, Mittal S. Demand vs Supply of Food in India - Futuristic Projection. Proceedings- Indian National Science Academy. 2016;82(5):1579-1586.