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Prospects of Increasing Income Through Optimum Production Pattern: A Linear Programming Approach

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ABSTRACT

The present study "Optimum production pattern for farmers in Obulavaripalli mandal of Kadapa district, Andhra Pradesh" was undertaken to examine the possibilities and prospects of increasing income through rational allocation of resources under different capital and technological environments. The study was carried out through collection of data by adopting interview method and linear programming technique was used to develop optimum plans for small and large farmers of the study area. The results of the study brought out that there was sub-optimal allocation of resources in the existing plans of small and large farms. The optimal plans indicated the possibilities of increasing income even under existing technology with limited available owned funds. The income was increased further through relaxation of credit and adoption of recommended technology.

Key words : Linear Programming Model, Optimum Plans, Rational Resource Allocation.

In agriculture, as in any other business, the efficiency is achieved by an optimum utilization of resources. Resources include land, labour, capital, irrigation facilities etc. Optimum allocation of land and other resources is defined as what crops 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 the farm return are maximum.

The present study is an attempt to analyse the possibilities and prospects of increasing the net farm income and employment by rational resource allocation through optimum production pattern.

MATERIAL AND METHODS

The present study was carried out in Kadapa district, as it is one of the agriculturally advanced districts of Aandhra Pradesh. From the district, Obulavaripalli mandal was selected as a representative of the district. All the villages in the selected mandal based on the gross cropped area were arranged in descending order and the first four villages were selected for a detailed study. From each village, ten small and ten large farmers were selected at random. Thus, the total number of farmers selected for the purpose of present study was 80. The data on technical coefficients and factor and product prices were collected from the selected respondents for the agricultural year 2004-2005 by survey method using a well structured questionnaire.

A one year (two seasons) linear programming technique was employed to develop optimum farm plans (Shareef and Krishna Murthy 2001) and also to estimate net farm returns and employment with existing and new technology under different capital environment.

In linear programming analysis, a linear function of a number of variables is to be maximised subject to a number of constraints in the form of linear equalities and inequalities. In mathematical form, the model can be expressed in the following way.

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

j= 1 to n activities subjected to following constraints

1. $\sum_{j=1}^{n} a_{ij} X_j \geq b_i \; (i = 1, \ldots\ldots K)$
2. $\sum_{j=1}^{n} a_{ij} X_j \leq b_i \; (i = K+1, \ldots\ldots m)$
3. $\sum_{j=1}^{n} a_{ij} X_j = b_i \; (i = m+1, \ldots\ldots v)$
4. $X_j, b_i \geq 0$ (non negativity constraint)

Table1. Cropping pattern for small farmers under different optimal plans.

Crop	Existing		S_1		S_2		S_3		S_4	
	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent
***Kharif* irrigated land**										
Paddy (ADT-37)	0.36	38.72	0.20	21.50	0.33	35.48	0.20	21.50	0.33	35.48
Bajra	0.20	21.50	-	-	-	-	-	-	-	-
Groundnut	0.13	13.98	-	-	0.15	16.13	-	-	0.15	16.13
Sunflower	0.06	6.45	0.28	30.11	0.30	32.26	0.03	3.23	0.30	32.26
Brinjal	0.10	10.75	0.15	16.13	0.15	16.13	0.15	16.13	0.15	16.13
Fallow	0.08	8.60	0.30	32.26	-	-	0.55	59.14	-	-
Total	**0.93**	**100.00**	**0.93**	**100.00**	**0.93**	**100.00**	**0.93**	**100.00**	**0.93**	**100.00**
***Rabi* irrigated land**										
Paddy (ADT-37)	0.10	10.75	-	-	-	-	-	-	-	-
Sunflower	0.32	34.41	0.28	30.11	0.28	30.11	-	-	-	-
Gingelly	0.12	12.91	-	-	-	-	0.52	55.91	0.28	30.11
Bhendi	0.06	6.45	-	-	-	-	-	-	-	-
Chillies	0.03	3.23	0.10	10.76	0.1	10.76	0.1	10.76	0.1	10.76
Onion	0.08	8.60	0.20	21.50	0.2	21.50	0.16	17.20	0.2	21.50
Tomato	0.06	6.45	0.20	21.50	0.2	21.50	-	-	0.2	21.50
Brinjal	0.10	10.75	0.15	16.13	0.15	16.13	0.15	16.13	0.15	16.13
Fallow	0.06	6.45	-	-	-	-	-	-	-	-
Total	**0.93**	**100.00**	**0.93**	**100.00**	**0.93**	**100.00**	**0.93**	**100.00**	**0.93**	**100.00**
Cropping Intensity	184.95		167.74		200.00		140.86		200.00	
Net Farm Returns (Rs.)	26,768		45,434		50,459		46,361		64,815	
Net farm Returns per hectare of Cultivated area (Rs.)	28,782.79		48,853.76		54,256.98		49,850.53		69,693.54	

Table 2. Cropping pattern for large farmers under different optimal plans.

Crop	Existing		L_1		L_2		L_3		L_4	
	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent
***Kharif* irrigated land**										
Paddy (JGL-1798)	0.40	14.08	0.60	21.13	0.76	26.76	0.60	21.13	0.76	26.76
Paddy (ADT-37)	0.52	18.31	-	-	-	-	-	-	-	-
Bajra	0.30	10.56	-	-	-	-	-	-	-	-
Groundnut	0.40	14.09	0.40	14.08	0.73	25.71	0.40	14.08	0.40	14.08
Sunflower	0.20	7.04	0.40	14.08	0.40	14.08	0.22	7.75	0.40	14.08
Bhendi	0.10	3.52	-	-	0.25	8.81	-	-	0.25	8.81
Tomato	0.15	5.28	-	-	-	-	-	-	0.33	11.63
Brinjal	0.20	7.04	0.30	10.56	0.30	10.56	0.30	10.56	0.30	10.56
Tumeric	0.25	8.81	0.35	12.32	0.40	14.08	0.34	11.97	0.40	14.08
Fallow	0.32	11.27	0.79	27.83	-	-	0.98	34.51	-	-
Total	**2.84**	**100.00**	**2.84**	**100.00**	**2.84**	**100.00**	**2.84**	**100.00**	**2.84**	**100.00**
***Rabi* irrigated land**										
Paddy (ADT-37)	0.40	14.08	0.20	7.04	0.22	7.75	-	-	0.17	5.99
Sunflower	0.72	25.35	0.80	28.17	0.80	28.17	0.8	28.17	0.80	28.17
Gingelly	0.48	16.90	0.18	6.34	0.37	13.03	0.64	22.54	0.75	26.41
Bhendi	0.18	6.34	0.25	8.81	-	-	-	-	-	-
Chillies	0.10	3.52	0.20	7.04	0.20	7.04	0.20	7.04	0.20	7.04
Onion	0.16	5.63	0.20	7.04	0.20	7.04	0.20	7.04	0.20	7.04
Tomato	0.15	5.28	0.35	12.32	0.35	12.32	0.35	12.32	0.02	0.71
Brinjal	0.20	7.04	0.30	10.56	0.30	10.56	0.30	10.56	0.30	10.56
Turmeric	0.25	8.81	0.35	12.32	0.40	14.08	0.34	11.97	0.40	14.08
Fallow	0.20	7.04	-	-	-	-	-	-	-	-
Total	**2.84**	**100.00**	**2.84**	**100.00**	**2.84**	**100.00**	**2.84**	**100.00**	**2.84**	**100.00**
Cropping Intensity	181.69		172.18		200.00		165.49		200.00	
Net Farm Returns (Rs.)	1,04,018		1,34,573.50		1,50,480		1,67,611.60		1,92,515.70	
Net farm Returns per hectare of Cultivated area (Rs.)	36,626.05		47,385.03		52,985.91		59,018.16		67,787.21	

where,

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

C_j= is the value or price 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 j^{th} activity

b_i = quantity of i^{th} resource

With the help of the above linear programming analysis, the following four optimum plans were developed for both small and large farms.

Model 1: S_1 for small farmers and L_1 for large farmers. In this model, cash availability of the farmers was restricted to owned funds. The technology considered in this model was based on the practices followed by the sample farmers in production of crops. This model was designed to asses the impact of reallocation of existing resources on net farm returns and cropping pattern.

Model 2: S_2 for small farmers and L_2 for large farmers. It is similar to model 1 but for the complete relaxation of the loan amount available to farmers. This model was developed to determine the maximum amount of short term loan required and also to examine the effect of credit on net farm returns.

Model 3: S_3 for small farmers and L_3 for large farmers. This model is similar to model 1 except that the recommended technology was incorporated in place of existing technology. Model 3 results indicate the income increasing possibilities by a switch over to the recommended technology even at the existing level of funds.

Model 4: S_4 for small farmers and L_4 for large farmers. It is similar to model 3 but for the complete relaxation of borrowing. This model would help to examine the effect of borrowing on new technology and consequential effect on net farm returns. In short this model was designed to asses the effect of modern technology in conjunction with adequate capital on the cropping pattern and also on income.

RESULTS AND DISCUSSION

The average land holding of small and large farmers in the study area worked out to be 0.93 hectare and 2.84 hectare of irrigated land respectively.

The existing production programme on both small and large farms included paddy, bajra, groundnut, sunflower, brinjal on *kharif* irrigated land. Paddy which is the main food crop of the study area occupied the largest area of 0.36 hectares (38.72%) and 0.92 hectares (32.39%) on small and large farms respectively. Bajra was grown on 0.20 and 0.30 hectares on small and large farms. Groundnut and sunflower which are the important oil seeds crops occupied 0.13 and 0.06 hectares on small farms accounting for 13.98 and 6.45 per cent of *kharif* irrigated land respectively. Large farmers allotted 0.40 hectares (14.09%) and 0.20 hectares (7.04%) for the production of groundnut and sunflower respectively. Large farmers allocated 0.10, 0.15 and 0.20 hectares of land during *kharif* for the production of vegetables *viz.,* bhendi, tomato and brinzal respectively. The existing plan of small farmers included only one vegetable enterprise during *kharif* i.e., brinjal. It occupied 0.10 hectares. Turmeric, an important commercial crop of the study area was grown on 0.25 hectares by the large farmers. The extent of uncultivated land on small and large farms was 0.08 and 0.32 hectares accounting for 8.60 and 11.27 per cent respectively (Table.1 & 2).

On both the size groups, larger proportion of land was occupied by oil seeds crops namely sunflower and gingelly during *rabi* season. They occupied 0.32 (34.41%) and 0.12 hectares (12.91%) on small farms and 0.72 (25.35%) and 0.48 hectares (16.90%) on large farms respectively. About 45 percent of the land was occupied by vegetable crops during rabi season on both farms.

The cropping intensity in the existing production programme was 184.95 per cent on small farms and 181.69 per cent on large farms. The net farm returns of the existing plan were Rs.26,768 and Rs.1,04, 018 on small and large farms respectively.

Cropping pattern and net farm returns under different optimum models:

The optimum model S_1 (Table 1) suggested to reduce the area for the production of paddy from 0.36 hectares in existing plan to 0.20 hectares during *kharif.* Bajra and groundnut which were in the existing plan were eliminated. However, the area under sunflower and brinjal increased from 0.06 and 0.10 hectares in the existing plan to 0.28 and 0.15 hectares in model S_1 respectively. The remaining 0.30 hectares (32.26%) of *kharif* irrigated land was kept fallow. In *rabi*, the results of the model indicated allocation of 0.10, 0.20 and 0.20 hectares for the cultivation of chillies, onion and tomato respectively. The area under sunflower declined from 0.32 hectares in the existing plan to 0.28 hectares in model S_1.

The other crops *viz.,* paddy, gingelly and bhendi did not find place in the optimum plan. Due to reorganization of resources, the cropping intensity decreased from 184.95 per cent in the existing plan to 167.74 per cent. The net farm returns and the net farm returns per hectare of cultivated area were of the order of Rs.45, 434 and Rs.48,853.76 respectively.

The land fallow in kharif in a country like ours where there is scarcity of land can not be accepted as a feasible solution. The fallow land appears to be mainly because of insufficient availability of funds. Hence the funds were increased by relaxing capital constraint to avoid fallow. Goundnut, an important enterprise of the study area which did not find the place in the optimum model S_1 entered the optimum plan S_2 with an area of 0.15 hectares. The model recommended to increase the area for the production of paddy from 0.20 hectares in model S_1 to 0.33 hectares, keeping the area under brinjal the same as in model S_1 during *kharif* season. Sunflower occupied 0.30 hectares of *kharif* irrigated land. During *rabi*, no change in crops was indicated by the optimum plan S_2. Sunflower, chillies, onion and tomato occupied the same extent of land as in model S_1. Due to complete utilization of land during *kharif*, the intensity of cropping increased from 167.74 per cent in model S_1 to 200 per cent in model S_2. The production programme indicated by model S_2 resulted in the realization of Rs.50, 459 as net farm returns.

In model S_3 during *kharif*, the area under brinjal remained the same in model S_3 as in previous models. The area under paddy declined from 0.33 hectares in model S_2 to 0.20 hectares. Sunflower occupied 0.03 hectares. During *rabi,* gingelly whch did not find place in the previous normative plans entered this plan with 0.52 hectares. This model suggested to keep 0.55 hectares (59.14%) of kharif irrigated land fallow because of shortage of capital. As a result the cropping intensity sharply declined to 140.86 percent. Even under restricted capital situation, capital was not found to be a limiting factor to adopt recommended technology in rabi season because of cash transfer activity from kharif to rabi build in the model. This model resulted in the realization of Rs.46,361 as net farm returns.

Model S_4 indicated complete utilization of land both in *kharif* and *rabi* seasons. As a consequence, the cropping intensity increased to maximum attainable levels. On *kharif* irrigated land, paddy, groundnut, sunflower and brinjal occupied the same extent of land as in the optimum model S_2. During *rabi*, chillies, onion and tomato were occupied the same area as in model S_1 and S_2. However, this model suggested to reduce the area for the production of gingelly from 0.52 hectares in model S_3 to 0.28 hectares. The cropping pattern suggested by model S_4 helped the small farmers to realize Rs.64,815 as net farm returns.

Model L_1 (Table 2)suggested less number of crops on *kharif* irrigated land by eliminating paddy (ADT-37), bajra, bhendi and tomato. Among the *kharif* crops, the most dominant enterprises in the optimal plan was paddy (JGL-1798) whose area increased from 0.40 hectares to 0.60 hectares. The normative plan also recommended to increase the area from 0.20, 0.20 and 0.25 hectares in the existing plan to 0.40, 0.30 and 0.35 hectares for the cultivation of sunflower, brinjal and turmeric respectively. During *rabi* season, the area under paddy (ADT-37) and gingelly declined from 0.40 and 0.48 hectares in the exiting plan to 0.20 and 0.18 hectares respectively. The plan recommended to increase the land use for the production of bhendi, chillies, onion and tomato by 0.07, 0.10, 0.04 and 0.20 hectares respectively over the existing plan. Brinjal and turmeric continued to occupy the same area as in *kharif* (Table.2). The resource optimization led to decrease in the intensity of cropping from 181.69 per cent in the existing plan to 172.18 per cent. With the reorganization of resources with the available funds, large farmers were able to realize Rs.1,34,573.50 as net farm returns.

On *kharif* irrigated land, the model L_2 included crops *viz.,* paddy (JGL-1798), sunflower, groundnut, bhendi, brinjal and turmeric with an area of 0.76, 0.40, 0.73, 0.25, 0.30 and 0.40 hectares respectively. The area under paddy (JGL-1798), groundnut and turmeric were increased by 0.16, 0.33 and 0.05 hectares respectively, over the optimum model L_1. No drastic change in the crops was indicated by the optimum model L_2 on rabi irrigated land. The area under gingelly increased by 0.19 hectares, over the model L_1. This could be due to elimination of bhendi which was in model L_1. The optimization with sufficient funds both owned and borrowed resulted in increase in the cropping intensity from 172.18 per cent in the model L_1 to 200 per cent in the model L_2. Large farmers realized Rs.1,50,480 as net farm returns.

The model L_3 suggested to reduce the land use for paddy (JGL-1798), sunflower, groundnut, turmeric from 0.76, 0.40, 0.73 and 0.40 hectares in the optimum model L_2 to 0.60, 0.22, 0.40 and 0.34 hectares during *kharif*. This model suggested to keep 0.98 hectares of *kharif* irrigated land fallow because of inadequacy of capital to implement

recommended technology which is capital intensive. The cropping pattern remained unaltered on *rabi* irrigated land except for the increase in the area under gingelly from 0.37 hectares in model L_2 to 0.64 hectares and elimination of paddy production. The intensity of cropping declined from 200 per cent in the previous model to 165.49 per cent. This model resulted in the realization of Rs.1,67,611.60 as net farm returns.

The normative plan L_4 recommended to cultivate paddy (JGL-1798), sunflower, bhendi, brinjal and turmeric with the same area as in model L_2 during *kharif* season. This model favoured inclusion of tomato which did not find place in the previous plans. During *rabi,* the model recommended to increase land for the production of gingelly from 0.64 hectares in model L_3 to 0.75 hectares. But the area under tomato declined from 0.35 hectares in previous optimum plans to 0.02 hectares. The results of optimum model L_4 revealed that it would be possible for large farmers to get Rs.1,92,515.70 as net farm returns. These findings are similar to the findings 0f Gajanana and Sharma(1990) and Deoghare(1997)

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