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RESEARCH ARTICLE :

Multi objective frame work for maximizing production, profit and land allocation goals at farm level in Villupuram District

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BACKGROUND AND OBJECTIVES

The study would bring out the sources of inefficiency in the production of crops along with constraining resources which would help the farmers in the reallocation of resources. The optimum plans developed under multi objective environment across scale of farming would bring the constraining resources and possibilities for bridging such resource gaps at different resource endowment levels prevailing in marginal, small and large farms.

The results would be of much help to the policy makers and planners to formulate appropriate policy packages and management strategies to correct the inefficiencies in allocation of resources and also in planning additional investment for agricultural development in block. It would also generate adequate information base for the use of academicians, extension workers and scientists.

With this view, the present study has been undertaken in Mailam block of Villupuram district to explore the efficiency of agricultural production and to develop optimum plans in a multi-objective frame work for maximizing production, profit and other farming goals at farm and block levels by using weighted goal programming model.

Objectives :

– To develop optimum agricultural farm plans for different farming situations in a multi-objective frame-work for improving production and profit and other farming goals with the available resources in the study area.
– To suggest appropriate policies and strategies needed for improving the agriculture consistent with multiple goals in the study region.

RESOURCES AND METHODS

Sampling procedure :

Villupurm district was purposively selected because it has more opportunity to cultivate more cereals and oilseed crops but the average land holding of farmers is very low when compare to other district. A two stage random sampling method was adopted to select the sample farms. At first stage, all the revenue villages were arranged in ascending order based on the gross cropped area in 2013-14 and 6 revenue villages were selected at random. Using the same criterion, all the cultivators in the each of the selected revenue villages were arranged and 10 farmers each from the selected six villages were selected at random, thus, constituting a total sample size of 60 farmers.

Tools of analysis :

Minimize $Z = \sum P_i (W_i^+ d_i^- + W_i^- d_i^-)$ (achievement function)

Subject to constraints :

$F_i (x) - d^+ + d_i^- - T_i$ (set of goals)

$x – b$ (set of linear constraints)

$x, d_i^+, d_i^- \geq 0$ (Non-negativity constraints)

$d_i^+, d_i^- = 0$ (for all goals)

Formulation of lexicographic goal programming model for farms :

The parameters of the operational model for different categories of farms are defined as follows.

x_j – area under j^{th} crop activity

Productive resources :

L_S = Total area of land currently in use for cultivating the crops ‘C’ in any season ‘S’ in hectares.

M_h = Total machine labours required during the year in hours

M_d = Total men labour required during the year.

Mw_h = Total women Labour required during the year

W_s = Total amount of water required during the season ‘S’ in ha cm.

T_{nf} = Total amount of nitrogen fertilizer required during the year in kilograms

T_{pf} = Total amount of phosporous fertilizer required during the year in kilograms

T_{kf} = Total amount of potash fertilizer required during the year in kilograms

T_c = Total amount of chemicals required during the year in kilograms

T_{fm} = Total amount of farmyard manure required during the year in kilograms

C_r = Total amount of cash required per annum for supply of productive resources in rupees.

M_p = Total profit for all the yielding crops in different season in a year in rupees.

Input co-efficients :

– Mh_{CS} = Average machine hours required per hectare

Table A : Distribution of respondents in sample Villages of Mailam block

Sr. No.	Selected villages	No. of respondents selected
1.	Mailam	10
2.	Chinnanerkunam	10
3.	Kolliyangunam	10
4.	Chendur	10
5.	Ganapathipattu	10
6.	Padhirapuliyur	10

Table B : Crop area coverage of selected villages (2013-14)

Sr. No.	Revenue villages	Area coverage (Ha)					Total
		Paddy	Millets	Pulses	Oilseeds	Sugar cane	
1.	Mailam	78	8	60	62	49	257
2.	Kolliyangunam	116	2	61	102	60	341
3.	Chinnanerkunam	142	11	111	99	107	470
4.	Chendur	130	9	99	123	127	488
5.	Ganapathipattu	113	18	87	94	71	383
6.	Padhirapuliyur	139	25	112	92	107	475

of land for cultivating the crop 'C' during the season 'S' in hours.

- MD_{CS} = Men Labour required per hectare of land for the crop 'C' during the season'S '.
- WMD_{CS} = Women Labour required per hectare of land for the crop 'C' during the season'S
- W_{cs} = Amount of water consumed per hectare of land for cultivating the crop 'C' during the season 'S' in ha cm
- F_{nfcs} = Amount of Nitroen fertilizer (in kg) required per ha of land cultivated under the crop 'C' during the season 'S' in kilograms.
- F_{pfcs} = Amount of phosporous fertilizer (in kg) required per ha of land cultivated under the crop 'C' during the season 'S' in kilograms.
- F_{kfcs} = Amount of potash fertilizer (in kg)required per ha of land cultivated under the crop 'C' during the season 'S' in kilograms.
- A_{cs} = Average cost of purchasing seeds and other materials per hectare of land for cultivating the crop 'C' during the season 'S' in rupees
- M_{pcs} = Profit per hectare of the crop 'C' cultivated during the season 'S' in rupees.

Then, the achievement function Z is minimized subject to the following operational goals and constraints.

- $\sum Mh_{CS}\, x_j\, d_1^- + d_2^- = M_h$
- $\sum MD_{CS}\, x_j\, d_1^- + d_2^- = M_d$
- $\sum W_{cs}\, x_j\, d_1^- + d_2^- = W_s$
- $\sum F_{fcs}\, x_j\, d_1^- + d_2^- = T_f$
- $\sum A_{cs}\, x_j\, d_1^- + d_2^- = C_r$
- $\sum M_{pcs}\, x_j\, d_1^- + d_2^- = M_p$
- $\sum x_j <= L_s$

OBSERVATIONS AND ANALYSIS

The optimum plan derived along with existing plan for marginal farm is presented in Table 1 and 2.

The existing plan for marginal farm had a gross cropped area 1.00 ha with 0.40 ha of *Rabi* paddy, 0.20 groundnut and 0.40 ha of blackgram. The existing plan utilized 65 men and women labour, eight hours of machine usage, 12.00 tonnes of farm yard manure, 120.00 kg of nitrogen 60.00kg of phosphorus 40.00 kg of potash, 5.46 ha cm of water, Rs.45260 as working capital, and earned a profit of Rs.50600.

It could be observed in the optimum plan that there was a decrease in the area under *Rabi* paddy and blackgram by 0.37 ha and 0.05 ha, respectively. Groundnut area increase 0.25 ha. The gross cropped area 1.00 ha in the existing plan had decreased to 0.83 ha

Table 1 : Area allocation for marginal farmers (Ha)

Sr. No.	Particulars	Existing plan	Optimal plan	Change in area and resource allocation
Area under different crops (in ha)				
1.	Paddy	0.40	0.03	-0.37
2.	Black gram	0.40	0.35	-0.05
3.	Groundnut	0.20	0.45	0.25
4.	Gross cropped area	1.00	0.83	-0.17

Table 2 : Resource utilization for marginal farmers

S. No.	Particulars	Existing plan	Optimal plan	Change in area and Resource allocation (%)
Resource utilization				
1.	Men labour (in hrs)	15	9.96	-33
2.	Women labour (in hrs)	50	20	-59
3.	Machine hours (in hrs)	8	8	0
4.	Farm yard manure (in tones)	12.00	7.0	-41
5.	Nitrogen (in Kg)	120	28	-75
6.	Phosphorus (in Kg)	60	29	-50
7.	Potash (in Kg)	40	38	-2
8.	Plant protection chemical (in Rs.)	2000	1633	-18
9.	Water consumption (in ha cm)	5.46	1.38	-74.72
10.	Working capital (in Rs.)	45260	38038	-15.95
11.	Profit (in Rs.)	50600	52600	

with the decrease utilization of 0.17 ha.

The optimal plan resulted in reduced utilization of resources to the tune of 50 per cent of potash when compared to the existing plan. In contrast, the optimum plan reduced the existing men and women labour requirement by 33 and 59 per cent , farmyard manure 7.00 tonnes, nitrogen 28 kg, phosphorus by 29 kg , water requirement by 1.38 ha cm and working capital by 38038.00 rupees. The optimum plan satisfied targeted profit goal and increased the profit by 2600.00 rupees. This clearly indicated the scope and superiority of the optimum plan over the existing plan in marginal farm.

The existing plan for small farm had a gross cropped area 2.03 ha with 0.81 ha of paddy, 0.81 ha black gram and 0.41 cholam. The existing plan utilized 95 men and women labour, 18.00 hours of machine usage, 16.50 tonnes of farm yard manure, 170 kg of nitrogen , 90kg of phosphorus, 45.00 kg of potash, 8.89 ha cm of water, Rs.45260 as working capital, and earned a profit of Rs.55600.

It could be observed in the optimum plan that there was decrease in the area under paddy by 0.67 ha, blackgram by 0.11 ha and cholam 0.08 ha. Maize was introduced as new enterprises into the optimum plan with an area of 0.72. The gross cropped area of 2.03 ha in the existing plan had increased to 2.16 ha with the additional utilization of 0.13 ha.

The optimal plan would result in the reduced utilization of resources to the tune of 14.57 per cent of farm yard manure, 46.05 per cent of plant protection chemicals and 19.12 per cent of nitrogen and no changes in phosphorus, potash, machine hours and 38038 rupees of working capital. The optimum plan satisfied targeted profit goal and increased the profit by reduction of resources prices. This clearly indicated the scope and superiority of the optimum plan over the existing plan in small farm.

The results revealed that the optimum plan increased the gross cropped area in the small farm by 0.13 ha over the existing plan with an additional profit and with a reduction in working capital by 15.95 per cent.

The optimum plan derived along with existing plan for large farmers is presented in Table 5 and 6.

The existing plan for large farm had a gross cropped area 4.45 ha with 0.81 ha of paddy 2.02 ha of sugarcane, 0.40 ha of groundnut ,0.81 ha of black gram and 0.41 ha of cholam. The existing plan utilized 520 number of men and women labour, 98 hours of machine usage, 50.10

Table 3 : Area allocation for small farmers (Ha)

Sr. No.	Particulars	Existing plan	Optimal plan	Change in area and resource allocation
Area under different crops (in ha)				
1.	Paddy	0.81	0.41	-0.67
2.	Black gram	0.81	0.70	-0.11
3.	Maize	-	0.72	0.72
4.	Cholam	0.41	0.33	-0.08
	Gross cropped area	2.03	2.16	0.13

Table 4 : Resource utilization for small farmers

Sr. No.	Particulars	Existing plan	Optimal plan	Change in area and resource allocation (%)
Resource utilization				
1.	Men labour (in hrs)	20	17.53	-12.37
2.	Women labour (in hrs)	85	57.72	-32.09
3.	Machine hours (in hrs)	18	18	0
4.	Farm yard manure (in tons)	16.50	14.09	-14.57
5.	Nitrogen (in Kg)	170	137.49	-19.12
6.	Phosphorus (in Kg)	90	90	0
7.	Potash (in Kg)	45	45	0
8.	Plant protection chemical (in Rs.)	3950	2130	-46.05
9.	Water consumption (in ha cm)	8.89	3.60	-59.5
10.	Working capital (in Rs.)	45260	38038	-15.95
11.	Profit (in Rs.)	55600	55600	

tonnes of farm yard manure, Rs 413500 as working capital, and earned a profit of Rs.867930.

It could be observed in the optimum plan that there was decrease in the area under paddy by 0.57 ha, sugarcane by 0.1 ha and black gram by 0.28 while there was increase in the area under groundnut by 0.72 ha and cholam by 2.98 ha. The gross cropped area of 4.45ha in the existing plan had increased to 7.2 ha with the additional utilization of 2.75ha.

The optimal plan would result in the reduced utilization of resources to the tune of 11.41 per cent of machine hours,10.27 per cent of farmyard manure,8.72 per cent of plant protection chemicals and 17.73 per cent of water consumption in ha cm. The optimum plan satisfied targeted profit goal and the profit by resources cost reduction. This clearly indicated the scope and superiority of the optimum plan over the existing plan in large farms.

The results revealed that the optimum plan increased the gross cropped area in the large farm by 2.75 ha over the existing and with a reduction in working capital by 0.10 per cent.

The above analysis indicated that the optimum plan for large farm had brought more profit, more allocation of land with reduction of labour, machine hours, Farm Yard Manure and water consumption.

Policy suggestion :

- Importance must be given to normative planning at micro and macro levels by offering flexibility in the availability of resources. Such normative agricultural planning through mathematical programming techniques should be undertaken in all the districts of Tamil Nadu for providing policy guidelines to the policy makers, administrators.
- Adoption of modern water conservation technologies and conjunctive use of water in the farms in short run and water resource planning with conservation and replenishment of water resources strategies at micro and macro levels in long run have to undertaken to address the issue holistically.
- Ensuring the availability of nutrients and empowering the farmers on integrated nutrient management through extension agency efforts may be needed to address the optimum utilization of nutrients. .
- The use of machineries for undertaking intercultural

Table 5 : Area allocation for large farmers (Ha)

Sr. No.	Particulars	Existing plan	Optimal plan	Change in area and resource allocation
Area under different crops (in ha)				
1.	Paddy	0.81	0.24	-0.57
2.	Sugarcane	2.02	1.92	-0.1
3.	Groundnut	0.40	1.12	0.72
4.	Blackgram	0.81	0.53	-0.28
5.	Cholam	0.41	3.39	2.98
	Gross cropped area	4.45	7.2	2.75

Table 6 : Resource utilization for large farmers

Sr. No.	Particulars	Existing plan	Optimal plan	Change in area and resource allocation (%)
Resource utilization				
1.	Men labour (in hrs)	240	239.47	-0.22
2.	Women labour (in hrs)	280	268.95	-3.95
3.	Machine hours (in hrs)	98	86.32	-11.41
4.	Farm yard manure (in tones)	50.10	44.9	-10.27
5.	Nitrogen (in Kg)	780	780	0
6.	Phosphorus (in Kg)	235	235	0
7.	Potash (in Kg)	295	295	0
8.	Plant protection chemical (in Rs.)	27000	24644	-8.72
9.	Water consumption (in ha cm)	39.49	21.76	-17.73
10.	Working capital (in Rs.)	413500	413070.6	-0.10
11.	Profit (in Rs.)	867930	867930	

operation may help to ease the situation of labour scarcity in the labour intensive crops.

– Farmyard manure scarcity was also indicated by optimal farm plans. With the ever dwindling cattle population, bridging this wide gap in the availability of farm yard manure calls for enhancing the production level of enriched farm yard manure, vermi-compost by using the available crop residues and other wastes in the farm level.

– Agriculture, following an integrated farming approach at micro and macro perspective is necessary for improving agriculture in Mailam block of Villupuram district.

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