RESEARCH ARTICLE

A LINEAR PROGRAMMING APPROACH TO CROPS AND LIVESTOCK ENTERPRISES PLANNING IN SUGARCANE BASED FARMING SYSTEM FOR MEDIUM CATEGORY OF FARMS IN DISTRICT MEERUT OF UTTAR PRADESH

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Received-02.06.2018, Revised-21.06.2018

Abstract: A livelihood system is the full range of activities available to the medium category of farms. The farmers are often faced with the problem of how to select the optimal cropping patterns that significantly contribute to sustainable production. The present study was conducted during the year 2013-14 in District Meerut of Uttar Pradesh to know the possibilities of optimum combination of different enterprises for the enhancement of the farms income and employment of medium category of farms household's. Multi stage stratified random sampling design was used to collect the primary data from; a sample of 19 respondents was selected on the basis of probability proportion to size of holdings. In this study, a linear program that reflects these choices by selecting a combination of farm activities that is feasible given a set of fixed farm constraints and that maximizes income while achieving other goals such as food security is developed. The results obtained by using the linear programming model are more superior. The difference in gross income is 25.08 per cent higher than the existing farm plan and labour man days 37.01 per cent higher compare to the existing farm plan.

Keywords: Linear programming, Whole-farm plan, Employment generation

INTRODUCTION

Agriculture has been a source of income for a significant percentage of India's population for centuries. Integrated activities of crop production, livestock raising still bear important roles in the subsistent farming systems in India. India is the world's second largest producer of sugarcane. Sugarcane is cultivated on 5.06 million ha. producing about 352.14 million tonnes of sugarcane with an average productivity of 69.84 tonnes per ha. during 2013-14. In India, area under sugarcane is highest, 22.12 lac. ha. in Uttar Pradesh, and production 130.50 million tonnes coupled with the productivity is 59.60 tonnes/ ha. during 2013-14. The Indian economy is predominantly rural and agricultural, and the declining trend in size of land holding poses a serious challenge to the sustainability and profitability of farming there by affecting the rural population. In view of the decline in per capita availability of land from 0.5 ha. in 1950-51 to 0.15 ha. by the turn of the century and a projected further decline to less than 0.1 ha. by 2020, No single farm enterprise is likely to sustain the farming by the Marginal, small and medium farmers without resorting to integrated farming systems (IFS) for the generation of adequate income and gainful employment round the year. (Behera and Mahapatra, 2004).

Their LP model considered both economic and environmental goals simultaneously in a composite objective function. The optimal plan obtained achieved 88 percent of the goals considered. Abdelaziz *et al* (2010) used LP technique to analyze data. The results of the analysis showed that the models gave a cropping pattern different from the existing farmers' production plan. The results from LP models gave a profit while the farmers' plan resulted in a loss (Abdelaziz *et al*, 2010).

Thus the average size of operational holding has declined to 1.15 ha. in 2010-11 as compared to 1.23 ha. in 2005-06.The semi-medium and medium operational holding (2.00 ha. – 10.00 ha.) in 2010-11 were 14.29 percent with the operated area at 44.88 percent. The corresponding figures for 2005-06 Censuses were 15.86 percent and 47.05 percent. In a total of 138.35 million operational holdings in the country, the highest one belonged to Uttar Pradesh (23.33 million) Agriculture census 2010-11. The objective of this paper is to examine the role and challenges of medium holding agriculture in achieving agricultural growth, food security and livelihoods in India. Medium holdings also face new challenges on integration of value chains, liberalization and globalization effects, market volatility and other risks and vulnerability, adaptation of climate change etc.

Mohamad and Said developed an LP crop mix model for a finite-time planning horizon. Given limited available resources such as budget and land acreage, the crop-mix planning model was formulated and transformed into a multi-period linear programming problem. The objective was the maximization of the total returns at the end of the planning horizon. Linear programming models have successfully been formulated under different scenarios to model different kinds of complexities.

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RESEARCH METHODOLOGY

Study Area

The study was conducted in Meerut district. Agriculture forms the economic base and the province is known for its rich soils. Traditionally, farmers depend on traditional methods, such as, instinct and experience, and comparisons with neighbours in order to make decisions about what commodities to produce and in what quantities. This does not guarantee optimal crop patterns. Effective tools like LP can address this problem. According to Hilderbrand and Cabrera, "Linear programming is a useful, and with the wide availability of laptop computers, easily available method for describing and analyzing family farm livelihood systems." Linear programming can be used to select optimal crop combinations subject to fixed farm constraints. The objective of this study is to address the resource allocation problem faced by a Medium-scale farmer in Meerut by applying LP.

District Meerut was purposively selected for present investigation. Being homogeneous of all the Blocks, two blocks were selected randomly i.e. Hastinapur and Sardhana. Three villages were selected randomly from each block. List of all the farmers of the selected villages was prepared according to their land holding size. A sample of 32 respondent having area upto 1-2 hectare were selected on the basis of probability proportional to their total numbers. Required primary data on crops, livestock and other allied enterprises was collected by personnel interviewed method and secondary data was also collected from various published sources. CACP cost concept and linear programming is a systematic and accurate method of determining mathematically the optimum combination of enterprises or inputs so as to maximize the income or minimize the cost within the limits of available resources.

Programming approach of the following form was used use to optimize the return from Sugarcane Based Farming System.

Objective function –I (Maximization of income)

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

Where,

Z = Net returns (income) variable cost in rupees

C_j= Net return over variable costs per unit of j-th activity in rupees

X_j = The level of j-th activity,

Subject to constraints:

$$\sum_{j=1}^{N} a_{ij} x_{ij} \leq b_i$$

Non-negative decision variable:

$Xij \geq 0$

Where:

a_{ij}= amount of i-th resource required for the j-th activity,

b_i = total available quantity of i-th resources.

i = 1, 2, 3,……..m, resources)

j = 1, 2, 3, …….n, activities)

The farmer must decide how many hectares that should be allocated to each activity. So the decisions are:

X_1 = hectares allocated for paddy production.

X_2 = hectares allocated for Jawar production.

X_3 = hectares allocated for sugarcane production.

X_4 = hectares allocated for wheat production.

X_5 = hectares allocated for potato production.

X_6 = hectares allocated for mustard production.

X_7 = hectares allocated for oat production.

X_8 = number allocated for buffalo rearing.

X_9 = number allocated for cow rearing.

The Linear Programming Formulation:

To visit the villages with prepared schedule and 120 respondents were selected on the basis of probability proportions to their population and 19 respondents were selected under medium category farms (2-4 hectares). The household is interested in cropping combination that helps them to maximize their total annual net returns and employment. Before the optimization model was constructed the household's existing plan was to allocate paddy, jowar, sugarcane, wheat, potato, mustard and oat were 0.52, 0.39, 1.63, 0.85, 0.82, 0.27 and 0.13 hectare respectively. Of prime importance is whether this crop enterprise production combination is optimal? Does it yield maximum net returns and employment? The resource constraints considered in this study, are land, labor and operating capital.

The goals of the objective function are to maximize income and employment generation and land allocation at subject to land, labor and cash available for production constraints.

The linear programming formulation for medium farmers was presented in the in the table 5.4.5. The average land holding size and labor availability of medium farm household in the study area was 2.56 ha and 360 man-days respectively in both the season. The working capital availability was Rs. 85640 and Rs. 83470 respectively in kharif and rabi season. The sugarcane production is important crop for attaining maximum return by the medium farmers in the study area which was included as minimum area constraint and value was 2.56 hectare land.

Table 1 represents the LP matrix. The Right Hand Side (RHS) represents the constraints on the resources.

Maximum Z-

$67749X_1+42493X_2+112026X_3+55179X_4+80334X_5+46222X_6+39639X_7+40786X_8+29225X_9-200X_{10}-200X_{11}-0.1X_{12}-0.1X_{13}$ (Objective function)

Subjected to

$X_1+X_2+X_3+ \leq 2.56$ (Kharif land constraints)

$X_3+X_4+X_5+X_6+X_7 \leq 2.56$ (Rabi land constraints)

$106X_1+36X_2+75X_4+34X_8+24X_9-1X_{10} \leq 360$ (Kharif labour constraints)

$73X_3+46X_4+73X_5+30X_6+31X_7+26X_8+21X_9-1X_{11} \leq 360$(Rabi labour constraints)

$29835X_1+14643X_2+29280X_3+31382X_8+26254X_9-1X_{12} \leq 85640$ (Kharif working constraints)

$26881X_3+25761X_4+62572X_5+17029X_6+14314X_7+30091X_8+24823X_9-1X_{13} \leq 83470$ (Rabi working constraints)

$X3 \geq 0.60$ (Minimum area constraints)

$X_1,X_2,X_3,\ldots\ldots\ldots..X_{13} \geq 0$ (non negative constraints)

Table 1. Linear Programming Matrix

Crop	**Paddy (0.30)**	**Jowar (0.21)**	**Sugarcane (0.59)**	**Wheat (0.35)**	**Potato (0.24)**	**Mustard (0.13)**	**Oat (0.05)**	**Buffalo* (1.3)**	**Cow* (1.1)**	**KHL**	**RHL**	**KB**	**RB**	**Constraints**
Variables	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	
Kharif Land (hectare)	1	1	1	-	-	-	-	-	-	-	-	-	-	≤ 2.56
Rabi Land (hectare)	-	-	1	1	1	1	1	-	-	-	-	-	-	≤ 2.56
Kahrif Laboure (man-days)	106	36	75	-	-	-		34	24	200	-	-	-	≤ 360
Rabi Laboure (man-days)	-	-	73	46	73	30	31	26	21	-	200	-	-	≤ 360
Kahrif working capital (Rs.)	29835	14643	29280	-	-	-	-	31382	26254	-	-	-1	-	≤ 85640
Rabi working capital (Rs.)	-	-	26881	25761	62572	17029	14314	30091	24823	-	-	-	-1	≤ 83470
Minimum area (hectare)	-	-	-	-	-	-	-	-	-	-	-	-	-	**≥ 0.60**
Net Return (Rs.)	67749	42493	112026	55179	80334	46222	39639	40786	29225	-	-	-	-	

KHL-Kharif Hired Laboure, RHL-Rabi Hired Laboure, KB- Kahrif Borrowing, RB-Rabi Borrowing

RESULT AND DISCUSSION

Optimum Combination of Different Enterprises

The linear programming formulation was solved by using computer based software and results of existing and optimum resource allocation plan of medium farmers are presented in table- 2. In existing plan area under paddy, jowar, sugarcane, wheat, potato, mustard and oat were 0.52, 0.39, 1.63, 0.85, 0.82, 0.27 and 0.13 hectare respectively whereas all the area in optimum farm plan covered fewer than three crops viz: sugarcane, potato and oat with 0.52, 0.25 and 0.52 hectare respectively and other crops were not feasible in selected area due to their minor importance in returns. Similarly buffalo and cow were in number of 3.30 and 2.15 respectively in the existing farm plan but due to greater importance of buffalo in planning, it appears 11.48 in numbers in to optimum farm plan.

Table 2. Optimum Combination of Different Enterprises Suggested by LP Model

Crop	Variables	Land Allocation			Labour			Net Return		
		Existing	Optimum	%Δ	Existing	Optimum	%Δ	Existing	Optimum	%Δ
Paddy	X_1	0.52	0	-100	55.12	0	-100	35229.48	0	-100
Jowar	X_2	0.39	0	-100	14.04	0	-100	16572.27	0	-100
Sugarcane	X_3	1.63	0.60	-63.19	241.24	88.08	-63.19	182602.40	67215.60	-63.19
Wheat	X_4	0.85	0	-100	39.10	0	-100	46902.16	0	-100
Potato	X_5	0.82	1.96	139.02	59.86	143.08	139.02	65873.88	76894.29	139.02
Mustard	X_6	0.27	0	-100	8.10	0	-100	12479.94	0	-100
Oat	X_7	0.13	1.96	1407.69	4.03	60.76	1407.60	5153.07	157454.64	1407.60
Buffalo	X_8	3.30	11.48	247.81	198	688.66	247.81	134593.80	468127.43	247.81
Cow	X_9	2.15	0	-100	96.75	0	-100	62833.75	0	-100
Total					**716.24**	**981.30**	**37.01**	**562240.70**	**703235.58***	**25.08**

Further linear programming resulted into a net return of □703235.58 in optimum farm plan as compared to □ 562240.72 in existing farm plan. There is an absolute improvement in net return which was 25.08 per cent higher than the existing farm plan. The land was fully utilized in optimum farm plan, whereas, requirement of labor man-days was 37.01 per cent higher in optimum farm plan than the existing farm plan. Analysis indicates that optimal farm plan seems more feasible because it create more opportunity for employment to the medium farm families in the study area. Thus from the optimal plans for medium categories of households, it could be inferred that there are significant potentials for income and employment generation in the study area.

The increased labour requirement has arisen, because the new optimal plans suggest inclusion of a higher number of the existing livestock species in the farming systems, which are believed to be labour intensive.

CONCLUSION

In this paper, a medium farm livelihood system in District Meerut of Uttar Pradesh is modelled with LP. The LP model developed solves the problem of how to select a combination of farm activities that is feasible given a set of fixed constraints and that maximizes profit while achieving other goals such as employment generation. Comparison of results obtained by using traditional method of planning and LP model reveal that results obtained from the LP model are more superior.

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