Visit us - www.researchjournal.co.in ■ DOI : 10.15740/HAS/IRJAES/8.2/287-292

International Research Journal of Agricultural Economics and Statistics

Volume 8 | Issue 2 | September, 2017 | 287-292 ■ e ISSN-2231-6434

Research Paper

Crop production planning for different size group of farmers using fuzzy multi objective linear programme

■ K.THOMAS FELIX, S. MURALI GOPAL AND S. SENTHILNATHAN

See end of the paper for authors' affiliations

Correspondence to :

K. THOMAS FELIX
Department of Economics, Tamil Nadu Agricultural University, COIMBATORE (T.N.) INDIA
Email : felixagri@yahoo.in

Paper History :
Received : *16.02.2017;*
Revised : *19.07.2017;*
Accepted : *01.08.2017*

ABSTRACT : Present study is an application of fuzzy optimization technique in agricultural planning particularly for farmers of Coimbatore district, Tamil Nadu, India. Generally the crop planning problem is formulated as linear programming problem but in real situation there are many uncertain factors in agricultural production planning problems. Therefore, future profit for crops is imprecise and uncertain. In this article an attempt is made to formulate a model for crop planning for different size group of farmers in Coimbatore district.

KEY WORDS : Fuzzy, Goal programming, Linear, Production planning

HOW TO CITE THIS PAPER : Felix, K. Thomas, Gopal, S. Murali and Senthilnathan, S. (2017). Crop production planning for different size group of farmers using fuzzy multi objective linear programme. *Internat. Res. J. Agric. Eco. & Stat.,* **8** (2) : 287-292, **DOI : 10.15740/HAS/IRJAES/8.2/287-292.**

INTRODUCTION :

Agriculture plays vital role in the Indian economy. India's geographical condition is unique for agriculture because it provides many favourable climatic conditions. There are plain areas, long growing season, fertile soil and wide variation in climatic condition. Apart from geographical conditions, India has been consistently making innovative efforts by using science and technology to increase production. In agricultural production planning problem, the major objective is to maximize the profit under the minimum investment with some other constrains. An important issue in this problems is to optimize the objectives, based on one or multi-objective optimization, one or more goal to be considered. Fuzzy mathematical programming has been developed in several research studies. One of the important early contributions in fuzzy programming was given by Zimmermann. In fuzzy multi-objective programming, Sakawa *et al.* (1987) have presented an interactive fuzzy approach for multi-objective linear programming problems. One of the main approaches in dealing with fuzzy models is the possibility theory. The basic work in possibility theory was introduced by Dubois and Prade.Their work has presented the foundation of the possibility programming approach, which has been applied to fuzzy linear single objective and multi objective programming.For agricultural production where uncertainty and vagueness effect the profit directly or indirectly, several researchers such as Slowinski (1986); Sinha *et al.* (1988); Sher and Amir (1994); Sumpsi *et al.* (1996); Sarker *et al.* (1997); Pal and Moitra (2003); Vasant (2003) and Biswas and Pal

(2005) used fuzzy goal programming techniques for farm planning problems. Lodwick *et al.* (2003) made a comparison of fuzzy stochastic and deterministic method in a case of crop planning problem followed by a study of Itoh *et al.* (2003) based on possibility measure. Itoh *et al.* (2003) considered a problem of crop planning under uncertainty assuming profit co-efficients are discrete random variables and proposed a model to obtain a maximum and minimum value of gains for decision maker. Sakawa and Yano (1986) and Chanas (1989) used various types of membership functions for obtaining compromise solution. Garg and Singh (2010) provided a procedure to solve MOLP using max. min. approach to build up the member ship function and stated that it provides superior results. These problems of allocation of land for different crops, maximization of production of crops, maximization of profit are addressed in agricultural management system. Maximization of crop production can't guarantee the maximization of profit. Profit or loss is also depending on fluctuating demand and cost for the particular crop. Also agriculture is a process that, at any moment of time associated with the issue of risk and there is no certainty.

MATERIALS AND METHODS :

First we introduce basic terms and definitions related to the paper and then mathematical formulation of the problems and finally the conclusion of the studies.

Multi objective linear programming problem:

In general, a multi objective optimization problem with k objectives, n variables and p constraints is as:

$$\text{Max } \{_1, Z_2, \ldots \ldots, Z_K\}$$

Such that

$$A_j \leq b \ldots \ldots j = 1, 2, \ldots ., p$$
$$X = \{_1, x_2, \ldots \ldots, x_n\},$$
$$x_i \geq 0, i = 1, 2, \ldots \ldots .. n$$

Fuzzy multi objective linear programming problem:

$$\text{Max } Z_1(x) = \textstyle\sum_{j=1}^{n} C_{1j} x_j$$

$$\text{Max } Z_2(x) = \textstyle\sum_{j=1}^{n} C_{2j} x_j$$

$$\text{Max } Zp(x) = \textstyle\sum_{j=1}^{n} C_{pj} x_j$$

$$p = 1,2,3,\ldots, m. \text{--------(1)}$$

Subject to $x£X,\{\}/A\ x \leq b,\ x \geq 0$

where, x is a n- dimensional vector of decision variable.

$Z_1(x), Z_2(x), \ldots \ldots .,(x)$ are p distinct linear objective functions of the decision variable x

C_{ij} is the cost factor vector,

$i = 1, 2, \ldots, mj = 1, 2, \ldots \ldots ., n$

A is m × n constraint matrix.

b is m dimensionsl vector of total resources available.

To find decision vector x,

$\ni (x) \geq (x^*)$ **For** $\forall p$

where, $Z_p(x^*)$, for $\forall p$ is our corresponding goal and all objective functions are to be maximized.

Objective functions of equation (I) are to be fuzzy constraints. If the tolerances of fuzzy constraints are given then a feasible solution set is characterized by its membership functions

$$(x) = \min \{«_1(x), «_2(x), \ldots \ldots, «_p(x)\}$$

The solution can be obtained by solving the problem of maximizing (x) subject to xεX.

i.e. $[\text{Min}_p \mu_p (x)]$ such that xεX.

Let $\gamma = \text{Min}_p \mu_p (x)$ be the overall satisfactory level of compromise then we get the equivalent model.

Maxy

Such that $\gamma \leq \mu_p$ for $\forall p$, xεX

Here membership functions of objective function is estimated by obtaining pay off matrix of positive ideal solution and assume that membership functions are of the type non decreasing linear or hyperbolic etc.

In this section, by using of fuzzy multi objective linear programming approach, computational algorithm for a scenario when production co-efficient are crisp discrete random variables given. There are three important seasons namely *Kharif* starting from June ending with October November,*Rabi* season starting from November ending with February-March and summer season starting March ending with May. The data for the planning year 2014–2015 were collected from different sources of agricultural planning units. The data on current total land area under cultivation, production and productivity of major crops from several issues of Season and crop report, The market prices of all the study crops were collected from Agmark website. The data on cash expenditure for utilisation of productive resources (seeds, man days, machine hours, water and fertilizer) per ha of land for major crops of Coimbatore were collected from the cost of cultivation scheme. After formatting the statistical data we have run the optimal programming problem on EXCEL SOLVER. We have obtained the optimal section of decision variables on two accounts for obtaining (1) Maximum production (2) Maximum profit. The different types of crops can be named as:

x_{12}-Sorghum,x_{21}-Paddy,x_{22}-Maize, x_{23}-Horsegram, x_{24}-Blackgram, x_{25}-Greengram, x_{31}-Paddy, x_{32}-Onion, x_{33a}-Banana, x_{34}-Groundnut, x_{35a}-Tapioca, x_{36a}Sugarcane.

This study included twelve crops, among this three of them are annual/perennial (Sugarcane, Banana and Tapioca).

Step 1 :

Solve the one objective function with constraint at time t, using linear programming techniques and then step by step find the corresponding value of all the objective functions for each of solutions.

Step 2 :

Then find lower bound Z_n' and upperbound Z_p'' for each objective.

$$\mu_p(X) = \begin{cases} 1 & \text{If } Z_p(X) \geq Z_p'' \\ \dfrac{Z_p(X) - Z_p^1}{Z_p'' - Z_p'} & \text{If } Z_p^1 < Z_p(X) \leq Z_p'' \\ 0 & \text{If } Z_p(X) \leq Z_p' \end{cases}$$

Step 3 :

Now transform multi objective linear programming problem into linear programming problem as Maxy

$$\mu_p(X) = \begin{cases} 1 \\ \dfrac{Z_p(X) - Z_p^1}{Z_p'' - Z_p'} \\ 0 \end{cases} \geq \gamma,\ x \in X,$$

where, $(x) = \sum_{j=1}^{n} C_{pj}x_j, 0 \leq \gamma \leq 1$

i.e. $Z_p(x) - \gamma\,(Z_p'' - Z_p') \geq Z_p'$

i.e. $\sum_{j=1}^{n} C_{pj}x_j - (Z_p'' - Z_p') \geq Z_p'$, for $\forall p$. It can easily solve by two phase simplex method.

RESULTS AND DATA ANALYSIS :

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Mathematical formulation of crop production problem :

The objectives of the problem are to maximize the production and profit. The computational algorithm developed above is implemented step by step to find a optimal solution of crop production for Coimbatore district, Tamil Nadu. This study was taken up in Coimbatore district of the Tamil Nadu state. Coimbatore district lies between 10"- 10' and 11"- 30' northern latitude and 76"- 40' and 77"- 30'eastern longitude. The total geographic area of the district is 4722 sq km. The population of Coimbatore district as per 2011 census was 3458045 with density of 731 people per sq km. The district had a population of 3,458,045 of which male and female were 1,729,297 and 1,728,748, respectively

In this district farmer mainly grows paddy, maize, horsegram, blackgram and greengram in *Kharif* season, sorghum in summer season. Paddy, onion and groundnut in *Rabi* season and they also cultivate annuals like sugarcane, banana and tapioca. The land available is 49191 hectare with given labour hours constrains. A small farm holder needs at least 600 kg of paddy and 200 kg of sorghum to meet out his annual food grains requirement.

Table 1 : The data description of productive resources and returns

Particulars	Man days /ha	Production kg/ha	Market price /q	Returns (Rs./ha)
Jowar (x_{12})	6.88	2493	1700	12370
Paddy (x_{21})	106.67	4800	1870	30031
Maize (x_{22})	105.43	5000	1450	19744
Horsegram (x_{23})	24.25	870	2900	4663
Blackgram (x_{24})	23.66	780	8819	23665.2
Greengram (x_{25})	21.11	878	5570	8559.6
Paddy (x_{31})	150.21	5780	1750	35853
Onion (x_{32})	58.16	12000	2000	130735
Banana (x_{33a})	299.2	40000	2000	648320
Groundnut (x_{34})	132.15	1900	4300	38200
Tapioca (x_{35a})	18.74	25000	1650	341610
Sugarcane (x_{36a})	275.13	110000	285	163500

The objectives of the problems are to maximize profit and production to provide minimum food grain requirement.

The objective functions are:

Production:

Maximize $Z_1 = 110000\ x_{36a} + 2493\ x_{12} + 4800\ x_{21} + 5000\ x_{22} + 870\ x_{23} + 780\ x_{24} + 878\ x_{25} + 5780\ x_{31} + 12000\ x_{32} + 40000\ x_{33a} + 1900\ x_{34} + 25000\ x_{35a}$

Profit :

Maximize $Z_2 = 163500x_{36a} + 12370\ x_{12} + 30031x_{21} + 19744x_{22} + 4663x_{23} + 870\ x_{23} + 23665.2x_{24} + 8559.6x_{25} + 35853x_{31} + 130735\ x_{32} + 648320\ x_{33a} + 38200x_{34} + 341610\ x_{35a}$

Subject to constraints:

Labour :

$275.13\ x_{36a} + 6.88\ x_{12} + 106.67\ x_{21} + 105.43\ x_{22} + 24.25\ x_{23} + 23.66\ x_{24} + 21.11\ x_{25} + 150.21\ x_{31} + 58.16\ x_{32} + 299.2\ x_{33a} + 132.15\ x_{34} + 18.74\ x_{35a} <= 400$

Land :

$x_{21} + x_{22} + x_{23} + x_{24} + x_{25} <= 49191$

$x_{31} + x_{32} + x_{34} <= 49191$

Water :

$x_{36a} + x_{12} + x_{33a} + x_{35a} <= 204.57$

$x_{21} + x_{22} + x_{23} + x_{24} + x_{25} <= 478.81$

$x_{31} + x_{32} + x_{34} <= 538.21$

Food requirement :

$2493x_{12} >= 200$

$4800\ x_{21} + 5780\ x_{31} >= 600$

Solve this linear programming problem by simplex method for objective function Z_1.

Production $Z_1 = 510854.05$

Profit = 6975442.45

Profit $Z_2 = 465942.6415$

Production = 46233.92944

Table 2 : Results of production maximization

x_{12}	0.080ha. land for sorghum
x_{21}	0.125 ha. land for paddy
x_{24}	0.128 ha. land for blackgram
x_{32}	0.016 ha. land for onion
x_{35a}	20.391 ha. land for tapioca

Table 3 : Results of profit maximization

x_{12}	0.469ha. land for sorghum
x_{21}	0.770 ha. land for paddy
x_{24}	0.128 ha. land for blackgram
x_{31}	1.077 ha. land for paddy
x_{32}	2.509 ha. land for onion
x_{35a}	0.196 ha. land for tapioca

First step is to run the first objective function (Z_1) using the above constraints, followed by we have to run the second objective function (Z_2) by solving these two objective function (Z_1 and Z_2) we get ideal solution of Z_1" Z_2' and Z_1' Z_2".

Table 4 : Positive ideal solution

	$Z_{1.}$	$Z_{2.}$
$Z_{1.}$	510854.1 = Z_1"	6975442=Z_2'
$Z_{2.}$	46233.93=Z_1'	465942.6=Z_2"

Z_1" – Maximised production from the first objective function

Z_2' – Maximised profit from the first objective function

Z_1' - Maximised profit from the second objective function

Z_2" - Maximised production from the second objective function

The third step is to maximize γ by including all the above constraints plus production and profit constraint, from than we get values of x_{12} , x_{21} , x_{22} , x_{23} ,x_{24} , x_{25}, x_{31} , $x_{32,}$ x_{33a}, $x_{34,}$ x_{35a} and x_{36a} using the values we can derive the optimal crop planning for different season and different size group of the farmers.

The objective function:

Maximize= 2.15E-06 γ +1.54E-07 γ

Subject to constraints :

Labour:

$275.13\ x_{36a} + 6.88\ x_{12} + 106.67\ x_{21} + 105.43\ x_{22} + 24.25\ x_{23} + 23.66\ x_{24} + 21.11\ x_{25} + 150.21\ x_{31} + 58.16\ x_{32} + 299.2\ x_{33a} + 132.15\ x_{34} + 18.74\ x_{35a} <= 400$

Land:

$x_{36a} + x_{12} + x_{33a} + x_{35a} <= 49191x_{21} + x_{22} + x_{23} + x_{24} + x_{25} <= 49191\ x_{31} + x_{32} + x_{34} <= 49191$

Water:

$x_{36a} + x_{12} + x_{33a} + x_{35a} <= 204.57$

$x_{21} + x_{22} + x_{23} + x_{24} + x_{25} <= 478.81$
$x_{31} + x_{32} + x_{34} <= 538.21$

Food requirement :

$2493x_{12} >= 200$
$4800\,x_{21} + 5780\,x_{31} >= 600$

Production :

Maximize $Z_1 = 110000\,x_{36a} + 2493\,x_{12} + 4800\,x_{21} + 5000\,x_{22} + 870\,x_{23} + 780\,x_{24} + 878\,x_{25} + 5780\,x_{31} + 12000\,x_{32} + 40000\,x_{33a} + 1900\,x_{34} + 25000\,x_{35a} - 464620.12\,\gamma >= 46233.92$

Profit :

Maximize $Z_2 = 163500x_{36a} + 12370\,x_{12} + 30031x_{21} + 19744x_{22} + 4663x_{23} + 870\,x_{23} + 23665.2x_{24} + 8559.6x_{25} + 35853x_{31} + 130735\,x_{32} + 648320\,x_{33a} + 38200x_{34} + 341610\,x_{35a} - 6509499.80\,\gamma >= 465942.64$

Using SOLVER, the result for the optimal crop planning model for area of different crops (in hacters) were given in Table 5.

Conclusion :

From the Table 6, The present study shows that, marginal farm holders can get 64295.60 kg of production (profit of Rs.8,68,298.94), small farm holders can get 65045.60 kg to 139295.60 of production (profit form Rs. 8,78,547.24 to Rs.18,93,128.94), semi medium farm holders can get 140045.60 kg to 289295.60 kg of production (profit from Rs.19,03,377.24 to Rs. 39,42,788.94), medium farm holders can get 290045.60 kg to 739295.60 kg of production (profit from Rs. 9,53,037.24 to Rs.1,00,91,768.94) and large farm holders can get 890045.60 kg. and above crop production of various crops during whole year and they will get the profit of Rs.1,21,51,677.24 and above.

Table 5 : Results of fuzzy multi objective linear programme

x_{12}	0.080ha. land for sorghum
x_{21}	0.125 ha. land for paddy
x_{24}	0.128 ha. land for blackgram
x_{31}	0.120 ha. land for paddy
x_{32}	0.016 ha. land for onion
x_{35a}	20.390 ha. land for tapioca
x_{36a}	0.1 ha. land for sugarcane

$\gamma = 0.99$

Table 6 : Combined crop planning for different size group of farmers **(Farm size in ha)**

Crop		Marginal	Small	Semi medium			Medium			Large
		<1.0	1.0 -1.99	2-2.99	3.0-3.99	4-4.99	5-7.49	7.5-9.99	10-11.99	12 and above
Kharif	x_{21}	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
	x_{24}	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128
	x_{35a}	0.74	0.75-1.74	1.75-2.74	2.75-3.74	3.75-4.74	4.75-7.24	7.25-9.74	9.75-11.74	11.75 and above
Rabi	x_{31}	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120
	x_{32}	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
	x_{35a}	0.85	0.86-1.85	1.86-2.85	2.86-3.85	3.86-4.85	4.86-7.35	7.36-9.85	9.86-11.85	11.86 and above
Pre	x_{12}	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080
	x_{35a}	0.91	0.92-1.91	1.92-2.91	2.92-3.91	3.92-4.91	4.92-7.41	7.42-9.91	9.92-11.91	11.92 and above

Authors' affiliations:
S. MURALI GOPAL AND S. SENTHILNATHAN, Department of Economics, Tamil Nadu Agricultural University, COIMBATORE (T.N.) INDIA

LITERATURE CITED :

Biswas, A.B. and Pal, B. (2005). Application of fuzzy goal programming technique to land use planning in agricultural system. *Omega*, **33**: 391-398.

Chanas, S. (1989). Fuzzy programming in multiobjective linear programming-A parametric approach, *Fuzzy Sets & Systems*, **29**: 303-313.

Garg, A. and Singh, S. R. (2010). Optimization under uncertainty in agricultural production planning, *I Concept Pocket J. Computational Intelligence for Financial Engineers*, **1**: 1-12.

Itoh,T,. Ishii, H. and Nanseki, T. (2003). Amodel of crop planning under uncertainty in agriculture management, *Internat. J. Prod. Econ.*, **81**: 555-558.

Lodwick, W., Jamison, D. and Russell, S.(2003). A comparison of fuzzy stochastic deterministic methods in linear programming, *Proceeding of IEEE*, 321-325.

Pal, B. B. and Moitra, B. M. (2003). Fuzzy goal programming approach to long term land allocation planning in agricultural system: A case study, Proceedings of fifth international conference on Advances in pattern recognition, Allied Publishers Pvt. Ltd.441- 447pp.

Sakawa,M . and Yano, H. (1986). Interactive fuzzy decision making for multiobjective non-linear programming using augmented minimax problems, *Fuzzy Sets & Syst.*, **20**: 31-43.

Sakawa, M., Yano, H. andYumine, T. (1987). An interactive fuzzy satisficing method for multi objective linear-programming problems and its application *IEEE Transactions on Systems, Man & Cybernetics*, **17**: 654–661.

Sarker, R.A., Talukdar, S. and Anwarul, Haque A.F.M. (1997). Determination of optimum crop mix for crop cultivation in Bangladesh. *Appl. Mathematical Modelling*, **21**: 621 632.

Sher, A. and Amir, I.(1994). Optimization with fuzzy constraints in agriculture production planning, *Agric. Syst.*, **45**: 421-441.

Sinha, S.B., Rao, K.A. and Mangaraj, B. K. (1988). Fuzzy goal programming in multicriteriadecision systems- A case study in agriculture planning. *Socio –Econ. Planning Sci.*, **22**(2): 93-101.

Slowinski, R.(1986). A multi criteria fuzzy linear programming method for water supply system development planning. *Fuzzy Sets & Syst.*, **19** : 217-237.

Sumpsi, J. M., Fransisco, Amador and Carlos, Romero (1996). On farmer's objectives: A multi criteria approach. *Europian J. Operation Res.*, **96**: 64-71.

Toyonaga,T., Itoh,T. and Ishii, H. (2005). A crop planning problem with fuzzy random profit co-efficients. *Fuzzy Optimization & Decision Making*, **4**: 51-59.

Vasant, P. M. (2003). Application of fuzzy linear programming in production planning, *Fuzzy Optimization & Decision Making*, **3**: 45-55.

Zimmermann, H. J. (1978). Fuzzy programming and linear programming with several objective functions, *Fuzzy Sets & Syst.*, **1**: 45-55.

Zimmermann, H. J. (1983). Fuzzy mathematical programming. *Computers & Operations Res.*, **10**: 291–298.