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Purpose of Fuzzy Goal Programming & Linear Programming with Different Objective Functions

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Abstract – This paper presents a purpose of fuzzy goal programming approach with different importance and priorities. Mathematical programming models for agricultural planning problem have been widely used since Heady [4] demonstrated the use of Linear Programming & Linear Planning (LP) for land allocation to crop planning problems. From 1960s to mid-1980s, LP models of different farm planning problems have been extensively studied. The potential use of LP for agricultural planning problem has been surveyed by Glen [2] in 1987.

Keywords: Agricultural, Linear programming; Fuzzy linear programming; Goal programming; Fuzzy goal programming; Land-use planning

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INTRODUCTION

The proposed model attempts to minimize total production and work force costs, carrying inventory costs and rates of changes in work force since LP is a single objective optimization technique and most of the farm planning problems is multi-objective in nature. The goal programming approach, one of the prominent tools for multi-objective decision analysis, to land allocation planning problem for optimal production of several crops was first introduced by Wheeler and Russell [11] in 1977. The purpose and potential of Goal Planning (GP) to farm planning problems have been surveyed by Romero [10]. The use of pre-emptive priority based GP to land use planning problem have been discussed by Pal and Basu [1].

Although GP has been widely used for farm planning problems, the main weakness of conventional GP formulation is that all the parameters of the problem need to be specified precisely in the planning environment. But in most of the practical decision problems, they are often imprecisely defined due to the expert's ambiguous understanding of the nature of these problems. So assigning of definite aspiration level to the goals of the problem frequently creates decision variable in most of the farm planning situations.

To overcome the above difficulty, the concept of fuzzy sets, initially proposed by Zadeh, has been introduced to the field of multi-objective optimization problem. The use of fuzzy linear programming (FLP) to farm planning problem has been discussed by Slowinski [12]. The fuzzy goal programming approach (FGP) to Crop planning problems in the environment of crisp resource constraints has been recently studied by Pal and Moitra [9]. However in contrast to LP and GP approach, fuzzy programming (FP) approach to farm planning problems has not appeared extensively in the literature. In this paper, a priority based FGP formulation for optimal production of seasonal crop by utilization of the cultivable land and the available productive resources is presented.

In the solution process, the sensitivity analysis with the variation of priority structure of the goals is performed to present how the sol^{n} is sensitive to change in priority structure.

Then the equal dean distance function is used to identify the appropriate priority structure under which the most satisfactory decision for the cropping plan can be reached in the decision making environment.

FGP PROBLEM FORMULATION:

In the fuzzy decision making environment, the objectives of the decision maker are always described fuzzily. Again the resources constraints may be crisp or fuzzy and that depends on the fuzziness of the available resources in the planning context. Let b_k be the aspiration level of the k_{th} goal objective $F_k(x) : (k = 1, 2, 3\ldots\ldots k)$ then the fuzzy goal may appear in one of the form $F_k(x) \lesssim b_k$ and $F_k(x) \gtrsim b_k$.

where, X is the vector decision variables and where $\gtrsim$ and $\lesssim$ indicate the fuzziness of ≥ and ≤ restrictions respectively.

Construction of Membership Function:

In fuzzy decision making situation, fuzzy goals are characterized by their membership function by defining the lower and upper tolerance limit and that depends on the fuzzy restriction given to a fuzzy goal of the problems.

Let t_{lk} and t_{uk} be the lower and upper tolerance limit respectively, for achievement of the aspired level b_k of the k^{th} fuzzy goal. Then the membership function $\mu_k(x)$ for the fuzzy goal $F_k(x)$ can be characterized as follows –

For type ≥ restriction:

$$\mu_k(x) = \begin{cases} 1 & if \quad F_k(x) \geq b_k \\ \dfrac{F_k(x) - (b_k - t_{lk})}{t_{lk}} & if \quad b_k - t_{lk} \leq F_k(x) \leq b_k \\ 0 & if \quad F_k(x) \leq b_k - t_{lk} \end{cases}$$

Where $(b_k - t_{lk})$ represent the lower tolerance limit for achievement of the stated fuzzy goal.

Again for ≤ type restriction:

$$\mu_k(x) = \begin{cases} 1 & if \quad F_k(x) \leq b_k \\ \dfrac{(b_k + t_{uk}) - F_k(x)}{t_{uk}} & if \quad b_k \leq F_k(x) \leq b_k + t_{uk} \\ 0 & if \quad F_k(x) \leq b_k + t_{uk} \end{cases}$$

Where $(b_k + t_{uk})$ represent the upper tolerance limit for achievement of the stated fuzzy goal. If the resources constraints are also considered as fuzzy then the membership function for them can be considered as ≤ type restriction and fuzzy object can be considered as type ≥ type restriction.

AN ILLUSTRATIVE CASE EXAMPLE

The land-use planning problem for production of the principle crops of the Nadia District in West Bengal (India) is considered to illustrate the proposed FGP model. The data of the planning year 1999-2000-2001 were collected from different agricultural planning units. The different types of seasonal crops and the decision variables representing them is given in table-1.

Table – 1

The summary of the seasonal crops and associated decision variable are –

Season s	Crop c	Variable x_{cs}
Pre Kharif (1)	Jute	x_{11}
	Sugarcane	x_{21}
	Aus	x_{31}
Kharif (2)	Aman	x_{42}
Rabi (3)	Boro	x_{53}
	Wheat	x_{63}
	Mustard	x_{73}
	Potato	x_{83}

The data for the aspiration levels of the fuzzy goals and their respective limits are given in table-2.

Table –2

Goal	Aspiration level	Tolerance limit	
		Lower	Upper
1. Land utilization			
(i) Pre-kharif season	272.135	–	309.33
(ii) Kharif season	272.135	–	309.33
(iii) Rabi season	272.135	–	309.33
2.(a) Machine hour	27843.75	29912.80	–
(b) Man-days hour	46510.66	43596.18	–
(c) Water consumption (in inch)			
(i) Pre-kharif season	2727.84	2524.34	–
(ii) Kharif season	1490.40	1437.60	–
(iii) Rabi season	5675.00	5605.20	–
(d) Fertilizer requirement (in metric ton)			
(i) Nitrogen	44.50	37.20	–
(ii) Phosphate	23.00	19.80	–
(iii) Potash	19.00	13.00	–
3. Cash Exp. (Rs.)	6441015.80	–	
4. Production			
(a) Jute	306.00	302.85	–
(b) Sugar Cane	259.00	81.50	–
(c) Rice	870.00	843.70	–
(d) Wheat	136.26	112.50	–
(e) Mustard	60.54	54.40	–
(f) Potato	110.00	98.60	–
5. Profit (Rs.)	12500000.00	11086621.61	–

The data description levels of the fuzzy goals and their productive resource utilization production rate and market price is given by table-3.

Table – 3

Production Activity	MH	MD	WC	FR			PA	CE	MP
				N	P	K			
Jute	61.02	125	60	20	20	20	2538.00	8577.98	980.00
Sugarcane	40.52	247	30	200	100	100	59283.00	23031.57	1500.00
Aus	61.02	84	25	40	20	20	2076.00	6700.97	646.00
Aman	40.52	89	12	20	20	20	1885.00	6811.57	540.00
Boro	38.51	111	48	100	50	50	3401.00	10508.44	564.50
Wheat	36.36	74	12	100	50	50	2301.00	7685.76	700.00
Mustard	36.36	47	6	80	40	40	795.00	5093.10	1150.00
Potato	36.36	119	20	150	75	75	17779.00	22527.05	190.00

Where,

MH = Machine Hour (hour/ha),

MD = Mandays (days/ha),

WC = Water Consumption (inch/ha),

FR = Fertilizer (kg/h),

PS = Production Achievement,

CE = Cash Expenditure,

MP = Market Price.

Now, we shall construct the fuzzy goals and their respective membership function.

CONCLUSION

The FGP approach to cropping plan in an agricultural system demonstrated in this paper provides a new look into the way of analyzing the different farm-related activities in an imprecise decision making environment. The main advantage of the proposed approach is that the decision for proper allocation of cultivable land for seasonal crops can be made on the basis of the need to society. Under the frame-work of the proposed model, different environmental constraints can easily be solved and a proper cropping plan can be made without involving any computational difficulty. An extension of the proposed approach for fuzzily described different input parameters involved with different form of linear programming problem. The method developed in this paper gives a new approach to handle complex agricultural planning situations in the multi-objective decision making problems.

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