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Function of Fuzzy Goal Programming & Linear Programming with different objective functions

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ABSTRACT :
This paper presents of a Fuzzy Goal Programming (FGP) approach with different importance and priorities. Mathematical programming models for agricultural planning problem have been widely used since heady 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 in 1987. It shows that solutions obtained by fuzzy linear programming are always efficient solutions. It also shows the consequences of using different ways of combining individual objective functions in order to determine an "optimal" compromise solution.

Key words : Fuzzy Goal Programming, Linear Planning, functions

INTRODUCTION :

The classical transportation problem is one of the sub classes of linear programming problem in which all constraints are inequality type. Hitchcock (1941) developed transportation model. Because of the complexity of the social and economic environment requires explicit consideration of criteria other than cost, the single objective transportation problems in real world cases can be formulated as multi-objective models. Charnes and Cooper (1961) first discussed on various approaches to solutions of managerial level problems involving multiple conflicting objectives. Ignizio (1978) applied goal programming for multiobjective optimization problems and solved twoobjective optimization problem. Some of the authors (see Garfinkl & Rao 1971; Swaroop et al., 1976) have solved the two objective problem by giving high and low priorities to the objectives. Belenson and Kapur (1973) presented two person-zero sum game approach consists of a p x p pay off matrix and solved each objective function individually finally developed best compromise solution using proper weights to the objective functions. Jimmenez and Vudegay (1999) solved a multi-criteria transportation problem using parametric approach by developing auxiliary solutions. Rakesh Varma et al., (1997) used fuzzy min operator approach to develop a compromise solution for the multi-objective problem. Ringuest and Rinks (1987) proposed two interactive algorithms for generating all non-dominated solutions and identified minimum cost solution as a best compromise solution. Gen et al., (1998) solved a bi-criteria transportation problem using hybrid genetic algorithm adopting spanning tree based prufer number to generate all possible basic solutions. Waiel. (2001) developed all non-dominated solutions and defined family of distance function to arrive a compromise solution.

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 are 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 serval crops was first introduced by wheeler and Russel in 1977. The purpose potential of Goal Planning (GP) to farm planning problems have been surveyed by Romero. The use of preemptive priority based GP to land use planning problem have been discussed by Pal and Basu.

Although GP has been widly 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 problem, they are often imprecisely defined due to the expert's ambiguous understanding of the nature of them. So assining 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 Zadah, 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. 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. However in contrast to LP and GP approach, fuzzy programming (FP) approach to farm planning problems has not been appeared extensively in the literature. In this paper, a priority based FGP formulation for optimal production of seasonal crop by utilization the cultivable land 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 equalidean 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 contex. 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.

$F_k(x) \gtrsim b_k$ and $F_k(x) \lesssim b_k$

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 follow –

For type ≥ type –

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

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

Again for ≤ type restriction:

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

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.

REVIEW OF RELATED STUDIES

The initial stage is to identify the statement of the problem and determine the attributes or criteria which have to be taken into further consideration to solve multiple-criteria decision-making (MCDM) problems. Subsequently, the appropriate data or information should be collected in order to construct the priorities among criteria. The next stage is to set up potential strategies or alternatives to ensure that the target can be achieved (Tzeng & Huang, 2014). Subsequently, potential alternatives can be assessed and enhanced by selecting a suitable method. MCDM problems are categorized into two classes: Multiple-Attribute Decision-Making (MADM) and Multiple-Objective Decision-Making (MODM) (Tzeng & Huang, 2014). However, conventional MCDM approaches only consider discrete problems and lack a common mechanism for particular current cases such as uncertain and group decisions. Often, MCDM problems utilize the fuzzy theory consisting of a set of goals, criteria (or attributes), and several alternatives. More accurately, in the fuzzy environment, MCDM problems can be classified into two categories: fuzzy MODM (FMODM) and fuzzy MADM (FMADM) problems (Glean J, 2012).

Multiple conflicting objectives can be seen in most current design, optimization, and scheduling problems. Nowadays, issues in various investigation fields such as sustainable development, environmental protection, output maximization, and so on are more focused than before (Hansen D.R., 2014). As a result of these elevating concerns, considering and defining more than one objective simultaneously for real-world problems has been continuously requested by experts. MOO is likewise identified as multi-performance optimization, multi-criteria optimization, and multi-objective programming. It is an area in MCDM that relates to optimizing mathematical problems in which more than one objective function has been considered, all of which have to be optimized simultaneously. For solving the optimization problems with one individual objective function, the goal is to get an optimal solution from a set of existing achievable solutions identified as single-objective optimization. If the problems consist of more than one objective function, the decision-maker discovers more optimal solutions identified as MOO (Ignizio J.P 2011). Finding a single solution for a MOP that meets all the objective functions is challenging. In this case, a set of feasible solutions generally are available.

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 1999-2001 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 Sugarcane Aus	x_{11} x_{21} x_{31}

Kharif (2)	Aman	x_{42}
Rabi (3)	Boro Wheat Mustard Potato	x_{53} x_{63} x_{73} 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) Prekharif 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) Prekharif 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 Expanture,
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 advantages 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, after 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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