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Triangular fuzzy number in probabilistic fuzzy goal programming with pareto distribution

Eka Susanti*, Oki Dwipurwani, Robinson Sitepu, Wulandari, Liani Natasia

Mathematics Departments, Faculty of Mathematics and Natural Science, Universitas Sriwijaya, Palembang, Indonesia

Email : *eka_susanti@mipa.unsri.ac.id

Abstract. In this paper we discuss about optimization problem in cake production at Yuli's home industry using Probabilistic Fuzzy Goal Programming (PFGP) models with Pareto Distribution. There are six kinds of cakes, namely *bolu kukus*, *kue lapis*, *kue pare*, *kumbu kacang*, *srikaya*, and *wajik*. This model has three goals, the first is maximum the profit, second minimum the amount of perishable cake, and the rest maximum the amount of best seller cake. PFGP models has been solved using fuzzy decisive method. The result, 4090 piece of bolu kukus, 2026 piece of kue lapis, 438 piece kue pare, 2620 piece of kumbu kacang, 17 piece of wajik and degree of membership is 0,9999991.

1. Introduction

Goal Programming (GP) is a special problem of linear programming. In GP there are deviational variables that state deviations in values obtained with the expected goals. The GP model is used on problems with several objectives to be achieved simultaneously. The GP model is widely used in planning and decision making activities in various fields. Such as in production, transportation, banking and finance, and others. [1] apply the GP models to transportation problems. [2] discuss about optimization of banks loan portofolio management using goal programming technique. [3] apply GP models in management financial problems. [4] discussed about optimization cost and time on project management. [5] apply GP problems for working capital. [6] applying weighted goal programming model for planning sustainable development to Gulf Cooperation Council Countries. [7] applying weighted goal programming to project management decisions with multiple goals.

On some issues, the expected value of goals cannot be clearly defined. To solve these problems can be done with a fuzzy approach. [8] used ant colony with fuzzy approach in GP models for selection machine problems. [9] used fuzzy goal programming models to solved transportation multiobjective. [10] discussed about multiobjective fuzzy chance constrained fuzzy goal programming. [11] applying genetic algorithm to solved fuzzy goal programming. [12] discuss fuzzy Goal Programming and Quality Function Deployment For New product Planning. [13] discuss about uncertaint goal programming in solid transportation problem. The goal programming models with fuzzy numbers is called the fuzzy goal programming (FGP) models.

In some real cases, the data used follows distribution and satisfied the assumptions of a statistical distribution. Problems with limited resources can be assumed to follow the Pareto distribution. A statistical approach can be used to solve these problems. The FGP models with statistical distribution is called the Probabilistic Fuzzy Goal Programming (PFGP) models. [14] provides a simple PFGP problem solving procedure, PFGP with weights and PFGP with priority. [15] discuss a hybrid

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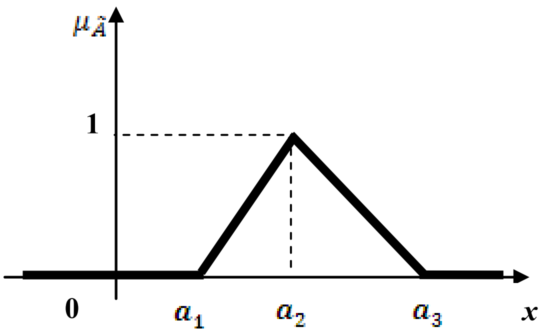
probabilistic fuzzy goal programming approach for agricultural decision-making. One of the fuzzy numbers that can be used is a triangular fuzzy number (TFN). [16] applied TFN on solid transportation problems and solved them with fuzzy decision set. In this paper a procedure for the completion of the introduced PFGP model (Barik 2015) is provided by minimizing deviations in cake production activities and goals stated in the TFN.

2. Triangular Fuzzy Number (TFN)

In this paper, the goals in the PFGP model are expressed as TFN. The membership function of the TFN introduced by [16] is given in Figure 1.



Where,

$$\mu_{\tilde{A}}(x) = \begin{cases} \dfrac{x - a_1}{a_2 - a_1}, for\ a_1 \le x \le a_2 \\ \dfrac{a_3 - x}{a_3 - a_2}, for\ a_2 \le x \le a_3 \\ 0, \quad elsewhere \end{cases}$$

Figure 1. TFN $\tilde{A} = (a_1, a_2, a_3)$

3. Probabilistic Fuzzy Goal Programming (PFGP)

The PFGP models is a linear goal programming model where goals are expressed with fuzzy numbers and constraints coefficients contain several random variables known to their distribution. The following is given the PFGP model given by [16].

Find $X = (x_1, x_2, \cdots, x_n)$ which optimizes the following fuzzy goals.

$$f_k(\boldsymbol{X}) \gtrsim g_k\ , k = 1,2, \cdots, K_0$$
$$f_k(\boldsymbol{X}) \lesssim g_k\ , k = K_0 + 1,2, \cdots, K_1$$
$$f_k(\boldsymbol{X}) \cong g_k\ , k = K_1 + 1,2, \cdots, K_2 \qquad (3.1)$$

Subject to

$$Pr\left(\sum_{j=1}^{n} a_{ij} x_j \le b_i\right) \ge 1 - \gamma_i\ ,\ i = 1,2, \cdots, m$$
$$x_j \ \ge 0, j = 1,2, \cdots, n$$

With

$0 < \gamma_i < 1, i = 1,2, \cdots, m$; $a_{ij}, i = 1,2, \cdots, m, j = 1,2, \cdots, n$ deterministic value.

$b_i, i = 1,2, \cdots, m$ random variable known by its distribution

[14] introduces the PFGP model with Pareto distribution and provides its application to production problems. The following is given a PFGP model with Pareto distribution

Find $X = \{x_1, x_2, \ldots, x_n\}$ to optimize the following fuzzy goals

$$f_k(X) \gtrsim g_k, \qquad k = 1,2, \ldots, K_0$$

$$f_k(X) \preccurlyeq g_k, \qquad k = K_0 + 1,2, \dots, K_1$$

$$f_k(X) \cong g_k, \qquad k = K_1 + 1,2, \dots, K_2 \tag{3.2}$$

constraints

$$\sum_{j=1}^{n} a_{ij} x_j \leq \frac{q_i}{(1-\gamma_i)^{\frac{1}{p_i}}}, \qquad i = 1,2, \dots, m, \; x_j \geq 0; \; j = 1,2, \dots, n$$

Where :

$f_k(X)$	objective function the k th
g_k	aspiration level of objective function k th
k	numbers of objective
K_0	total number *fuzzy goal* kind of *fuzzy-max* ($\succcurlyeq$)
K_1	total number *fuzzy goal* kind of *fuzzy-min* ($\preccurlyeq$)
K_2	total number *fuzzy goal* kind of *fuzzy-equal* ($\cong$)
a_{ij}	decisions variable coeffisien j th in constraint i th
j	activities that use available resources or facilities
i	total sources constraint or facilities are available
γ_i	probability value of constraints
p_i	Shape parameter *i* th
q_i	Measure parameter *i* th
x_j	Decisions variable *j* th

3.1. PFGP Models with Pareto Distribution and TFN

PFGP Models with Pareto Distribution and TFN is a PFGP model with Pareto distribution in which the goals are expressed by TFN and stated as follows.

Minimum

$\sum_{i=1}^{k}(Z = d_i^+ + d_i^-)$

Subject to

$$f_k(x) - d_k^+ = g_k, k = 1, \cdots, K_0, \; g_k = (a_1, a_2, a_2)$$
$$f_k(x) + d_k^- = g_k, k = K_0 + 1,2, \dots, K_1, \; g_k = (a_1, a_1, a_2) \tag{3.3}$$
$$\sum_{j=1}^{n} a_{ij} x_j \leq \frac{q_i}{(1-\gamma_i)^{\frac{1}{p_i}}}, \qquad i = 1,2, \dots, m$$
$$x_j \geq 0, \qquad j = 1,2, \dots, n$$

Where

d_k^+ = above deviational of goal k th

d_k^- = bottom deviational of goal k th

3.2. Fuzzy Decisive Set Method

[16] introducing fuzzy decisive set method to solve fuzzy multi-objective linear program problems with fuzzy resources by determining values g_k, l_k, u_k. where

g_k= aspiration level for the goal k th
l_k = lowest tolerance for the goal k-th
u_k = highest tolerance for the goal-th

Algorithm

Step 1. Determine individual solution for each

Step 2. Determine $g_k, l_k, u_k, z_{1,} g_0$

Step 3. Transformation (3) to deterministic form, obtained

Maks λ
Subject to
$\lambda \leq \frac{z_1 - Z}{z_1 - g_0}$
$g_0 \leq Z \leq z_1$
$\lambda \leq \frac{f_k(x) - d_k^+ - l_k}{g_k - l_k}, k = 1, \cdots, K_0$
$l_k \leq f_k(x) - d_k^+ \leq g_k, k = 1, \cdots, K_0$
$\lambda \leq \frac{u_k - (f_k(x) + d_k^-)}{u_k - g_k}, k = K_0 + 1,2, \dots, K_1$ (3.4)
$g_k \leq f_k(x) + d_k^+ \leq u_k, k = K_0 + 1,2, \dots, K_1$
$\sum_{j=1}^{n} a_{ij} x_j \leq \frac{q_i}{(1-\gamma_i)^{\frac{1}{p_i}}}, \quad i = 1,2, \dots, m$
$x_j \geq 0, \lambda \in [0,1]$ for $j = 1,2, \dots, n$
where
g_0 = the goal of total deviationaluntuk jumlah deviasional
z_1 = total of tolerance deviational

4. Result and Discussion

This section discusses optimization problems that minimize deviational totals from three goals in Yuli's cake. These three goals are goals that maximize profits, minimize the number of perishable cakes and maximize the number of best seller cakes. The three goals are each stated in the form of a TFN. Yuli's industry produces several types of traditional cakes including bolu kukus, kue lapis, kue pare, kumbu kacang, srikaya dan wajik. Each cake has a different ingredients. It is assumed that the total supply of ingredients every week as a random variable is Pareto distribution. Based on the results of an interview with Mrs Yuli, the average weekly gain obtained by Yuli's industry was Rp. 8,488,570 and the lowest profit obtained by Mrs Yuli was Rp. 2,790,585. The advantages of pieces of bolu kukus, kue lapis, kue pare, kumbu kacang, srikaya dan wajik are respectively Rp.980, Rp.787, Rp.749, Rp.971, Rp.1023 and Rp.813. Pare cakes and Srikaya are cakes that perishable, the average production of perishable cakes every week is 1,295 pieces and the highest number of production is 1785 pieces. In addition to cakes that are perishable, there are three cakes that best seller, including bolu kukus, kue lapis, and kumbu kacang. The average selling price of cakes every week is 8,736 pieces. The lowest amount of production from fast cakes sells as many as 2660 pieces. The following is given data on the total ingredients inventory in Yuli's industry.

Table 1. Inventory of Ingredients Every Week

No.	Kind of Ingredients	Amount of Ingredients every cake (Kg)						Estimation ingredients every week (Kg)
		Bolu Kukus (x_1)	Kue Lapis (x_1)	Kue Pare (x_1)	Kumbu Kacang (x_1)	Srikaya (x_1)	Wajik (x_1)	
1	Red Sugar	-	-	-	-	-	0.00267	6.2
2	Sugar	0.01	0.01	0.0144	0.007	0.0167	0.0067	134.5
3	Peeled Green Beans	-	-	0.0144	-	-	-	15.4
4	Red Beans	-	-	-	0.013	-	-	35.5
5	coconut	-	-	-	0.008	-	-	21
6	Sticky rice	-	-	-	-	-	0.014	35.7
7	Coconut milk	-	0.0245	-	-	0.0167	0.014	131.5
8	egg	0.008	-	-	-	0.04	-	48.9
9	Tapioca	-	0.01	-	-	-	-	43
10	Sticky rice flour	-	-	0.01	-	-	-	11.9
11	Wheat flour	0.005	-	-	-	-	-	20.

Source : Yuli's home industry

PFGP models to optimize cake production at Yuli's home industry

$$\textbf{Min } (d_1^+ + d_2^+ + d_1^-)$$

Subject to

$$980x_1 + 787x_2 + 749x_3 + 971x_4 + 1.023x_5 + 813x_6 - d_1^+ = 8.4\widetilde{88.5}70$$
$$x_3 + x_5 + d_1^- = \widetilde{1.295}$$
$$x_1 + x_2 + x_4 - d_2^+ = \widetilde{8.736}$$
$$0{,}00267x_6 \le \frac{6{,}2}{(1-0{,}03)^{\frac{1}{5{,}8}}}$$
$$0{,}01x_1 + 0{,}01x_2 + 0{,}0144x_3 + 0{,}007x_4 + 0{,}0167x_5 + 0{,}0067x_6 \le \frac{134{,}5}{(1-0{,}1)^{\frac{1}{6{,}98}}}$$
$$0{,}0144x_3 \le \frac{15{,}4}{(1-0{,}04)^{\frac{1}{6{,}92}}}$$
$$0{,}013x_4 \le \frac{35{,}5}{(1-0{,}02)^{\frac{1}{6{,}92}}} \tag{4.1}$$
$$0{,}008x_4 \le \frac{21}{(1-0{,}01)^{\frac{1}{7}}}$$
$$0{,}014x_6 \le \frac{35{,}7}{(1-0{,}02)^{\frac{1}{6{,}90}}}$$
$$0{,}0245x_2 + 0{,}0167x_5 + 0{,}014x_6 \le \frac{131{,}5}{(1-0{,}09)^{\frac{1}{7{,}05}}}$$
$$0{,}008x_1 + 0{,}04x_5 \le \frac{48{,}9}{(1-0{,}08)^{\frac{1}{7{,}04}}}$$
$$0{,}01x_2 \le \frac{43}{(1-0{,}07)^{\frac{1}{7{,}14}}}$$
$$0{,}01x_3 \le \frac{11{,}9}{(1-0{,}05)^{\frac{1}{8{,}45}}}$$
$$0{,}005x_1 \le \frac{20{,}4}{(1-0{,}06)^{\frac{1}{25}}}$$
$$x_1,\ x_2,\ x_3,\ x_4,\ x_5,\ x_6 \ge 0 \textit{ and integer},\ d_1^+, d_2^+, d_1^- \ge 0.$$

Given probability value or significance every random variable b_i was ditermined base on inventory data of ingredients and given at Table 1. $\gamma_1 = 0.03,\ \gamma_2 = 0.1,\ \gamma_3 = 0.04,\ \gamma_4 = 0.02,\ \gamma_5 = 0.01,$ $\gamma_6 = 0.02, \gamma_7 = 0.09,\ \gamma_8 = 0.08,\ \gamma_9 = 0.07,\ \gamma_{10} = 0.05,$ dan $\gamma_{11} = 0.06$

Parameter a_{ij} with $i = 1,2,3,4,5,6,7,8,9,10,11$ and $j = 1,2,3,4,5,6$ is deterministic of models and right hand variable b_i, $i = 1,2,3,4,5,6,7,8,9,10,11$ is random variable Pareto distribution with average value ($E(b_i)$) and variance ($\mathrm{Var}(b_i)$) is given, let $E(b_i)$ and $\mathrm{Var}(b_i)$, $E(b_1) = 7.5; E(b_2) = 157; E(b_3) = 18; E(b_4) = 41.5; E(b_5) = 24.5; E(b_6) = 41.75; E(b_7) = 153.25; E(b_8) = 57; E(b_9) = 50; E(b_{10}) = 13.5; E(b_{11}) = 21.25.$

$Var\ (b_1) = 2.25; Var\ (b_2) = 709.02; Var\ (b_3) = 9.52; Var\ (b_4) = 50.58; Var(b_5) = 17.15;$
$Var(b_6) = 51.56; Var(b_7) = 659.54; Var(b_8) = 91.56; Var(b_9) = 68.13; Var(b_{10}) = 3.34;$
$Var(b_{11}) = 0.79$

Scale for every parameter q_i,
$q_1 = 6.2; q_2 = 134.5; q_3 = 15.4; q_4 = 35.5; q_5 = 21; q_6 = 35.7;$
$q_7 = 131.5; q_8 = 48.9; q_9 = 43;\ q_{10} = 11.9;\ q_{11} = 20.4$

Determine p_i
$p_1 = 5.8; p_2 = 6.98; p_3 = 6.92; p_4 = 6.92; p_5 = 7; p_6 = 6.90;$
$p_7 = 7.05; p_8 = 7.04; p_9 = 7.14;\ p_{10} = 8.45;\ p_{11} = 25$

TFN for profit is **(2,790.585;8,488,570; 8,488,570).**
TFN for perishable cake is **(1,295;1,295;1,785).**
TFN for bestseller cake is **(2,660; 8,736; 8,736)**.
Parameter and variable used in PFGP models given in Table 2.

Table 2. Parameter and Variabel

No.	Parameter	Definition
1.	a_{ij}	ingredients i th for cake j th
2.	γ_i	Probability value of constraints i th
3.	p_i	shape parameter i th in constraints
4.	q_i	Scale parameter i th in constraints
5.	i	Ingredients are used
6.	j	Kind of cake
	Variabel	Definition
1.	x_1	Amount of bolu kukus
2.	x_2	Amount of kue lapis
3.	x_3	Amount of kue pare
4.	x_4	Amount of kumbu kacang
5.	x_5	Amount of srikaya
6.	x_6	Amount of wajik

Step 1. Determine individual solution

$$\begin{aligned}
&\textbf{Min } (\boldsymbol{Z} = d_1^+ + d_2^+ + d_1^-)\\
&\textbf{Subject to}\\
&980x_1 + 787x_2 + 749x_3 + 971x_4 + 1.023x_5 + 813x_6 - d_1^+ = 8.488.570\\
&x_3 + x_5 + d_1^- = 1.295\\
&x_1 + x_2 + x_4 - d_2^+ = 8.736\\
&0{,}00267x_6 \leq 6{,}2327\\
&0{,}01x_1 + 0{,}01x_2 + 0{,}0144x_3 + 0{,}007x_4 + 0{,}0167x_5 + 0{,}0067x_6 \leq 136{,}5456\\
&0{,}0144x_3 \leq 15{,}4911\\
&0{,}013x_4 \leq 35{,}6038\\
&0{,}008x_4 \leq 21{,}0302\\
&0{,}014x_6 \leq 35{,}8047\\
&0{,}0245x_2 + 0{,}0167x_5 + 0{,}014x_6 \leq 133{,}2710\\
&0{,}008x_1 + 0{,}04x_5 \leq 49{,}4826\\
&0{,}01x_2 \leq 43{,}4393\\
&0{,}01x_3 \leq 11{,}9725\\
&0{,}005x_1 \leq 20{,}4506\\
&x_1,\ x_2,\ x_3,\ x_4,\ x_5,\ x_6 \geq 0 \textit{ and integer},\ d_1^+, d_2^+, d_1^- \geq 0.
\end{aligned} \tag{4.2}$$

Using Lingo 17 Software, obtained results $x_1 = 1765$, $x_2 = 4343$, $x_3 = 1075$, $x_4 = 2628$, $x_5 = 220$, $x_6 = 0, Z = 241094, d_1^+ = 241094, d_2^+ = 0, d_1^- = 0$

$$\begin{aligned}
&\textbf{Min } (\boldsymbol{Z} = d_1^+ + d_2^+ + d_1^-)\\
&\textbf{Subject to}\\
&980x_1 + 787x_2 + 749x_3 + 971x_4 + 1.023x_5 + 813x_6 - d_1^+ = 2.790.585\\
&x_3 + x_5 + d_1^- = 1.785\\
&x_1 + x_2 + x_4 - d_2^+ = 2.660\\
&0{,}00267x_6 \leq 6{,}2327\\
&0{,}01x_1 + 0{,}01x_2 + 0{,}0144x_3 + 0{,}007x_4 + 0{,}0167x_5 + 0{,}0067x_6 \leq 136{,}5456\\
&0{,}0144x_3 \leq 15{,}4911\\
&0{,}013x_4 \leq 35{,}6038\\
&0{,}008x_4 \leq 21{,}0302\\
&0{,}014x_6 \leq 35{,}8047\\
&0{,}0245x_2 + 0{,}0167x_5 + 0{,}014x_6 \leq 133{,}2710
\end{aligned} \tag{4.3}$$

$0{,}008x_1 + 0{,}04x_5 \leq 49{,}4826$
$0{,}01x_2 \leq 43{,}4393$
$0{,}01x_3 \leq 11{,}9725$
$0{,}005x_1 \leq 20{,}4506$
$x_1,\ x_2,\ x_3,\ x_4,\ x_5,\ x_6 \geq 0\ and\ integer,\ d_1^+, d_2^+, d_1^- \geq 0.$

Obtained the results $x_1 = 1$, $x_2 = 2659$, $x_3 = 927$, $x_4 = 0$, $x_5 = 1$, $x_6 = 2, Z = 857$
$d_1^+ = 0$, $d_2^+ = 857, d_1^- = 0$

Step 2. Set goals
Goals are determined base on solution in the step 1

Step 3. Solve Deterministic Models

Deterministic form Problems (5) is

$\boldsymbol{Maks\ \lambda}$

Subject to

$$
\begin{aligned}
& d_1^+ + d_2^+ + d_1^- + 240237\lambda \leq 241094 \\
& 857 \leq d_1^+ + d_2^+ + d_1^- \leq 241.094 \\
& 980x_1 + 787x_2 + 749x_3 + 971x_4 + 1.023x_5 + 813x_6 - d_1^+ - 5697985\lambda \geq 2.790.585 \\
& 2.790.585 \leq 980x_1 + 787x_2 + 749x_3 + 971x_4 + 1.023x_5 + 813x_6 - d_1^+ \leq 8.488.570 \\
& x_3 + x_5 + d_1^- + 490\lambda \leq 1.785 \\
& 1.295 \leq x_3 + x_5 + d_1^- \leq 1.785 \\
& x_1 + x_2 + x_4 - d_2^+ - 6076\lambda \geq 2.660 \\
& 2.660 \leq x_1 + x_2 + x_4 \leq 8.736 \\
& 0{,}00267x_6 \leq 6{,}2327 \\
& 0{,}01x_1 + 0{,}01x_2 + 0{,}0144x_3 + 0{,}007x_4 + 0{,}0167x_5 + 0{,}0067x_6 \leq 136{,}5456 \\
& 0{,}0144x_3 \leq 15{,}4911 \\
& 0{,}013x_4 \leq 35{,}6038 \\
& 0{,}008x_4 \leq 21{,}0302 \\
& 0{,}014x_6 \leq 35{,}8047 \\
& 0{,}0245x_2 + 0{,}0167x_5 + 0{,}014x_6 \leq 133{,}2710 \\
& 0{,}008x_1 + 0{,}04x_5 \leq 49{,}4826 \\
& 0{,}01x_2 \leq 43{,}4393 \\
& 0{,}01x_3 \leq 11{,}9725 \\
& 0{,}005x_1 \leq 20{,}4506 \\
& x_1,\ x_2,\ x_3,\ x_4,\ x_5,\ x_6 \geq 0\ and\ integer,\ d_1^+, d_2^+, d_1^- \geq 0.
\end{aligned}
\tag{4.4}
$$

Obtained the results $x_1 = 4090$, $x_2 = 2026$, $x_3 = 438$, $x_4 = 2620$, $x_5 = 0$, $x_6 = 17$
$d_1^+ = 0$, $d_2^+ = 0, d_1^- = 857, \boldsymbol{\lambda = 0{,}9999991}$

a goal that minimizes the upper deviational amount is achieved, this can be seen from the value $d_1^+ = 0$, $d_2^+ = 0, d_1^- = 857,\ \lambda = 0{,}9999991$. This means that to earn a profit of Rp 8,488,570 per week, the amount of perishable cake production is 1295 pieces and the number bestseller cake production is 8736 pieces Mrs.Yuli can produce 4090 pieces of bolu kukus, 2026 kue lapis, 438 Pare cake, 2620 pieces of kumbu kacang, and 17 pieces of wajik.

5. Conclusion

In this paper, the minimum goal is the amount of deviation that maximizes profits, minimizes the amount of cake that is **perishable** and maximizes the amount of cake that is **best seller** as stated by the TFN. The completion of the PFGP model with Pareto distribution on the optimization problem of production activities using fuzzy decision set methods gets the value $d_1^+ = 0$, $d_2^+ = 0$, $d_1^- = 857$, $\lambda = 0{,}9999991$. Its means that the expected goals can be achieved and the fuzzy decision set method can be applied to complete the PFGP model with Pareto distribution with goals stated with the TFN.

References

[1] S M Kommerce, G R Babu and M Madhubala, "Goal Programming Model for Transportation Problems," *Int. J. Comput. Sci. Inf. Technol.* **4** (1) 43–48, 2011.
[2] M C Agarana, S A Bishop and O A Odetunmibi 2014 optimization of banks loan portfolio management using goal programming technique *Int. J. Res. Applied, Nat. Soc. Sci* **2** (8) 43–52
[3] B Abdul H Abd, N Abdullah and N Faradilah 2015 Bank Financial Statement Management using a Goal Programming Model, in *Procedia - Social and Behavioral Sciences*, **211** 498–504.
[4] A Yahiya-Berrouiguet and K Tissourassi 2015 Application of goal programming model for allocating time and cost in project management : a case study from the company of construction seror, *Yugosl. J. Oper. Res.*, **25** (2) 283–289.
[5] M Dash and R Hanuman 2015 A Goal Programming Model for Working Capital," *J. Manag. Sci.*, **5** (1) 7–16.
[6] R Jayaraman, C Colapinto, D La and T Malik 2016 A Weighted Goal Programming model for planning sustainable development applied to Gulf Cooperation Council Countries, *Appl. Energy* **185** (2), 1931–1939.
[7] D S Hada 2017 Applying Weighted Goal Programming to Project Management Decisions with Multiple Goals, *Indian J. Sci. Res.* **15** (1) 100–108.
[8] F T Chan and R Swarnkar 2006 Ant colony optimization approach to a fuzzy goal programming model for a machine tool selection and operation allocation problem in an FMS, *Robot. Comput. Integr. Manuf.* **22** 353–362.
[9] S G Acharyulu and K V V C Mouli 2011 Fuzzy Goal Programming Method for SolvingMulti-Objective Transportation Problems, *Glob. J. Res. Eng.*, **11** (3) 3–9.
[10] A K Bhargava 2014 Multi-Objective Fuzzy Chance Constrained Fuzzy Goal Programming for Capacitated Transportation Problem, *Int. J. Comput. Appl.*, **107** (3) 18–24.
[11] P Biswas 2015 Fuzzy Goal Programming Approach to Solve Linear Multilevel Programming Problems using Genetic Algorithm, *Int. J. Comput. Appl.*, **115** (3) 10–19.
[12] L Chen, W Ko and F Yeh 2016 Approach Based on Fuzzy Goal Programming and Quality Function Deployment For New product Planning , *Eur. J. Oper. Res.* **259** (2) 654–663.
[13] L Chen, J Peng and B Zhang 2016 Uncertain Goal Programming Models for Bicriteria Solid Transportation Problem," *Appl. Soft Comput. J.*
[14] S Barik 2015 Probabilistic Fuzzy Goal Programming Problem Involving Pareto Distribution : Some Additive Approaches , *Fuzzy Inf. Eng.* **7** 227–244.
[15] R K Jana, D K Sharma, and B Chakraborty 2016 A hybrid probabilistic fuzzy goal programming approach for agricultural decision-making , *Intern. J. Prod. Econ.*, **173** 134–141.
[16] B Jana and T K Roy 2005 Multi-Objective Fuzzy Linear Programming and Its Application in Transportation Model, *Tamsui Oxford J. Math. Sci.* **21** (2). 243–268.