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RESEARCH ARTICLE

APPLICATION OF GOAL PROGRAMMING APPROACH FOR RUBBER MADE FURNITURE SPECIALLY WOOD DOOR MANUFACTURING FACTORY IN TRIPURA: A COMPARATIVE STUDY

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Abstract

Rubber plantation requires re-planting after 31-35 years when latex collection becomes uneconomical. For commercial utilization and value addition to rubber logs felled during re-plantation, processing of Rubber Timber is vital; otherwise, there is no timber value. Restriction on the use of forest timber inspired the establishment of the Rubber Wood manufacturing unit. The carpentry unit plays an important role in popularizing the use of eco-friendly Rubber wood in the country. Making of doors from solid rubber wood and treated timber has good market in the country as plenty of houses are being built in the country. Additionally, Rubber Wood Door has enormous export potential. Sen and Nandi (2012) developed a mathematical model in their paper. In this paper, I consider four cases that change the basic structure of the model, and a comparative study is conducted.

Introduction:-

One of the biggest industries in the northeastern states is the Tripura Rubber Industry. The state, which is recognized as the second-largest producer of rubber in the country, closely behind Kerala in terms of rubber production. In the state, rubber plantations have proliferated. As a result of the rise in rubber output, Tripura's rubber industry has grown to be a significant industrial enterprise.

The natural rubber industry is one of the principal thrust sectors in the state economy. Rubber production is expected to generate substantial revenue for the state in the coming years. The Tripura Incentive Scheme provides several beneficial facilities to aid the growth of rubber-based industries in the state. Rubber logs have no market value unless they are chemically treated followed by scientific seasoning. It is cost-effective to make furniture out of rubber wood.

Rubber wood doors have a sizable domestic market as well as promising export prospects. Rubber wood is mostly used to make two types of doors: panel doors and main doors. When making doors, solid rubber wood board and treated rubber wood can be utilized as raw materials. Such an industry has a significant impact on the economy and is financially profitable.

Application of Mathematical Approaches:

Sen and Nandi (2012), reviewed many studies by scholars in the field of manufacturing industries. They reviewed the studies of Field (1973), Krishna Rustagi (1973), Duangsathaporn and Prasomsin (2005), Suresh Chand Sharma

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et al. (2010), Gomez et al. (2006), Sadjadi and Arabzadeh (2008), Roetter et al. (2000). They have studied many types of mathematical approaches.

Problem Statement:
Based on the data collected from the secondary sources, TFDPC, TRPC and small-scale manufacturing industries, a comparative study was carried out on rubber wood door manufacturing factories in Tripura. For the proposed model, different goals are prioritized with rank of order and various cases of the original model which are themselves different models have been studied and validated with the available data. Four models including the original one have been solved and analyzed. In the second model, the change in priority factor between the third constraint of the first goal and the third constraint of the second goal with the first and second constraints of the fourth goal have been considered and analyzed. In the third model, the change in priority factor between the first and second constraints of fourth goal with the first and second constraints of the fifth goal have been considered and analyzed. In the fourth model, the change in priority factor between the third constraint of the first goal and the third constraint of the second goal with the first and second constraints of the fifth goal have been considered and analyzed. In all the models, the main aim is to minimize the labor cost budget and material cost budget, and to maximize the number of finished products- that is to maximize the number of main and panel doors. A priority based linear goal programming technique was used to study the different models.

Mathematical Models:
Here is a numerical representation of Sen & Nandi's (2012) original model. For detail discussion of the model, one can go through paper.

In this paper, a priority based linear goal programming technique has been used for rubber made wood door manufacturing in Tripura which will cover by and large all relevant factors. To understand the GP model, the symbols used and model components i.e. goal constraints and achievement function are explained.

Priorities of goals:
The following is a definition of the problem's priority level based on the decision-making environment:

The manufacturer establishes the following priorities:

Goal	Priority
Skilled and unskilled Labours, Material type-1 and material type-2,	P_1
Finished Product	P_2
Budgeted allocation for labours and materials	P_3
Maximum utilization of both types of labours and materials	P_4
Profit	P_5

Achievement function:
Minimize Z = $P_1(d_1^{L+} + d_2^{L+} + d_1^{M+} + d_2^{M+}) + P_2 d_1^{FP-} + P_3(d_4^{L+} + d_4^{M+}) + P_4(d_3^{L-} + d_3^{M-}) + P_5(d_1^{MD-} + d_1^{PD-})$

Application of proposed model with Numerical Illustration- Model-1:
Data collected for the said model may vary time to time, which indicates that we can also modify proposed model to get the optimum result. In this problem door making is considered. Making of window, bench, table, chair, cot, computer table may be considered and for this purpose new models may be formulated.

Subject to goal constraints

$$P_1: \quad x_1^L + d_1^{L-} - d_1^{L+} = b_1^L$$
$$P_1: \quad x_2^L + d_2^{L-} - d_2^{L+} = b_2^L$$
$$P_4: \quad x_1^L + x_2^L + d_3^{L-} - d_3^{L+} = b^L$$
$$P_1: \quad x_1^M + d_1^{M-} - d_1^{M+} = b_1^M$$
$$P_1: \quad x_2^M + d_2^{M-} - d_2^{M+} = b_2^M$$

$$P_4: \quad x_1^M + x_2^M + d_3^{M-} - d_3^{M+} = b^M$$
$$P_2: \quad c_1^{FL} x_1^L + c_2^{FL} x_2^L + c_1^{FM} x_1^M + c_2^{FM} x_2^M + d_1^{FP-} - d_1^{FP+} = b^{FP}$$
$$P_3: \quad c_1^L x_1^L + c_2^L x_2^L + d_4^{L-} - d_4^{L+} = b^{BL}$$
$$P_3: \quad c_1^M x_1^M + c_2^M x_2^M + d_4^{M-} - d_4^{M+} = b^{BM}$$
$$P_5: \quad c^{MD} x^{MD} + d_1^{MD-} - d_1^{MD+} = b^{MD}$$
$$P_5: \quad c^{PD} x^{PD} + d_1^{PD-} - d_1^{PD+} = b^{PD}$$

Explanation of symbols:
Decision variables:
x_1^L =No. of skilled labors.
x_2^L =No. of unskilled labors.
x_1^M =No. of units of solid wood board.
x_2^M =No. of units of treated timber.
x^{MD} =No. of units of main doors.
x^{PD} =No. of units of panel doors.
d^-, d^+ = Deviational variables.
Where, d^- = under achievement of goal, d^+ = over achievement of goal.

Coefficients and constants:
b_1^L = Minimum no. of units of skilled labor.
b_2^L = Minimum no. of units of unskilled labour.
b_1^M = Minimum no. of units of solid wood board.
b_2^M = Minimum no. of units of treated timber.
b^L = Maximum no. of units of labours.
b^M = Maximum no. of units of materials.
b^{FP} =No. of units of finished product.
b^{BL} =Total budget for all labors.
b^{BM} = Total budget for all types of materials.
b^{MD} = Total profit for main doors.
b^{PD} = Total profit for panel doors.
c_1^L =Cost per unit for skilled labor for whole work.
c_2^L = Cost per unit for unskilled labor for whole work.
c_1^M = Cost per unit for solid wood board.
c_2^M = Cost per unit for treated timber.
c_1^{FL} =Units of x_1^L skilled labour.
c_2^{FL} = Units of x_2^L unskilled labour.
c_1^{FM} =Units of x_1^M solid wood board.
c_2^{FM} = Units of x_2^M treated timber.
c^{MD} = Profit per unit for main door.
c^{PD} = Profit per unit for panel door.

The above model was developed from the information based on the survey regarding rubber plantation in Tripura. Collected data are presented in tabular form in table 1 and table 2.

Table 1:- Summary of relevant data of parameters.

c_1^{FL}	c_2^{FL}	c_1^{FM}	c_2^{FM}	c_1^L (in Rs)	c_2^L (in Rs)	c_1^M (in Rs)	c_2^M (in Rs)	c^{MD} (in Rs)	c^{PD} (in Rs)
0.25	0.23	0.4	0.3	90000	81000	600	500	1100	950

Table 2:- Summary of data related to bounds on system constraints and target.

b_1^L	b_2^L	b^L	b_1^M (in cft)	b_2^M (in cft)	b^M (in cft)	b^{FP} (nos.)	b^{BL} (in Rs)	b^{BM} (in Rs)	b^{MD} (in Rs)	b^{PD} (in Rs)

100	65	175	37000	18500	58000	18200	14260000	31209000	11050000	7607000

Different cases of the above model:

The present study will give insight about the effects on the model when priorities are rearranged. Accordingly, I have considered three different cases which are also treated as different models.

Model -2: Changing priority factor between third constraint of first goal and third constraint of second goal with first and second constraints of fourth goal.

Minimize $Z = P_1(d_1^{L+} + d_2^{L+} + d_1^{M+} + d_2^{M+}) + P_2 d_1^{FP-} + P_3(d_4^{L+} + d_4^{M+}) + P_4(d_3^{L-} + d_3^{M-}) + P_5(d_1^{MD-} + d_1^{PD-})$

Subject to goal constraints

$$P_1:\quad x_1^L + d_1^{L-} - d_1^{L+} = b_1^L$$
$$P_1:\quad x_2^L + d_2^{L-} - d_2^{L+} = b_2^L$$
$$P_3:\quad x_1^L + x_2^L + d_4^{L-} - d_4^{L+} = b^L$$
$$P_1:\quad x_1^M + d_1^{M-} - d_1^{M+} = b_1^M$$
$$P_1:\quad x_2^M + d_2^{M-} - d_2^{M+} = b_2^M$$
$$P_3:\quad x_1^M + x_2^M + d_4^{M-} - d_4^{M+} = b^M$$
$$P_2:\quad c_1^{FL}x_1^L + c_2^{FL}x_2^L + c_1^{FM}x_1^M + c_2^{FM}x_2^M + d_1^{FP-} - d_1^{FP+} = b^{FP}$$
$$P_4:\quad c_1^L x_1^L + c_2^L x_2^L + d_3^{L-} - d_3^{L+} = b^{BL}$$
$$P_4:\quad c_1^M x_1^M + c_2^M x_2^M + d_3^{M-} - d_3^{M+} = b^{BM}$$
$$P_5:\quad c^{MD}x^{MD} + d_1^{MD-} - d_1^{MD+} = b^{MD}$$
$$P_5:\quad c^{PD}x^{PD} + d_1^{PD-} - d_1^{PD+} = b^{PD}$$

Model -3: Changing priority factor between the first and second constraints of fourth goal with the first and second constraints of fifth goal.

Minimize $Z = P_1(d_1^{L+} + d_2^{L+} + d_1^{M+} + d_2^{M+}) + P_2 d_1^{FP-} + P_3(d_4^{L+} + d_4^{M+}) + P_4(d_3^{L-} + d_3^{M-}) + P_5(d_1^{MD-} + d_1^{PD-})$

Subject to goal constraints

$$P_1:\quad x_1^L + d_1^{L-} - d_1^{L+} = b_1^L$$
$$P_1:\quad x_2^L + d_2^{L-} - d_2^{L+} = b_2^L$$
$$P_4:\quad x_1^L + x_2^L + d_3^{L-} - d_3^{L+} = b^L$$
$$P_1:\quad x_1^M + d_1^{M-} - d_1^{M+} = b_1^M$$
$$P_1:\quad x_2^M + d_2^{M-} - d_2^{M+} = b_2^M$$
$$P_4:\quad x_1^M + x_2^M + d_3^{M-} - d_3^{M+} = b^M$$
$$P_2:\quad c_1^{FL}x_1^L + c_2^{FL}x_2^L + c_1^{FM}x_1^M + c_2^{FM}x_2^M + d_1^{FP-} - d_1^{FP+} = b^{FP}$$
$$P_5:\quad c_1^L x_1^L + c_2^L x_2^L + d_1^{MD-} - d_1^{MD+} = b^{BL}$$
$$P_5:\quad c_1^M x_1^M + c_2^M x_2^M + d_1^{PD-} - d_1^{PD+} = b^{BM}$$
$$P_3:\quad c^{MD}x^{MD} + d_4^{L-} - d_4^{L+} = b^{MD}$$
$$P_3:\quad c^{PD}x^{PD} + d_4^{M-} - d_4^{M+} = b^{PD}$$

Model -4: Changing priority factor between third constraint of first goal and third constraint of second goal with first and second constraints of fifth goal.

Minimize $Z = P_1(d_1^{L+} + d_2^{L+} + d_1^{M+} + d_2^{M+}) + P_2 d_1^{FP-} + P_3(d_4^{L+} + d_4^{M+}) + P_4(d_3^{L-} + d_3^{M-}) + P_5(d_1^{MD-} + d_1^{PD-})$

Subject to goal constraints

$$P_1:\quad x_1^L + d_1^{L-} - d_1^{L+} = b_1^L$$
$$P_1:\quad x_2^L + d_2^{L-} - d_2^{L+} = b_2^L$$
$$P_5:\quad x_1^L + x_2^L + d_1^{MD-} - d_1^{MD+} = b^L$$
$$P_1:\quad x_1^M + d_1^{M-} - d_1^{M+} = b_1^M$$

$$P_1: \quad x_2^M + d_2^{M-} - d_2^{M+} = b_2^M$$
$$P_5: \quad x_1^M + x_2^M + d_1^{PD-} - d_1^{PD+} = b^M$$
$$P_2: \quad c_1^{FL} x_1^L + c_2^{FL} x_2^L + c_1^{FM} x_1^M + c_2^{FM} x_2^M + d_1^{FP-} - d_1^{FP+} = b^{FP}$$
$$P_3: \quad c_1^L x_1^L + c_2^L x_2^L + d_4^{L-} - d_4^{L+} = b^{BL}$$
$$P_3: \quad c_1^M x_1^M + c_2^M x_2^M + d_4^{M-} - d_4^{M+} = b^{BM}$$
$$P_4: \quad c^{MD} x^{MD} + d_3^{L-} - d_3^{L+} = b^{MD}$$
$$P_4: \quad c^{PD} x^{PD} + d_3^{M-} - d_3^{M+} = b^{PD}$$

Solution:
The models outlined above have been solved by LING 13.0 using the table 1 and table 2. The results obtained in initial model and its three different cases are shown in table 3. More over table 4 shows the extent to which target goals in different models mentioned above are achieved.

Analysis of the Results & Discussion:-

Analysis of the Results of First Model:
It is clear from the analysis of the first model that the minimization of overutilization of unskilled labor and second-type material is fully achieved. Under achievement value 1 in case of utilization of skilled labors and under achievement value 401.6667 in case of utilization of 1st type material indicate that one more skilled labor may be hired and 401.6667 more units of 1st type material may be utilized for making of doors. The result also reveals that the number of finished products, that is, doors, may be 2029 units more than the target figure. Minimization of underachieving profit for main doors and panel doors is fully achieved. The result of the 1st model also reveals that the target value of the material cost budget is fully achieved, but the achievement value of 85000 in the labor cost budget suggests that there are savings of Rs. 85000 in the labor cost budget. Under achievement value 11, the utilization of the maximum number of both types of labor may be 11 units less than the desired value, and under achievement value 2901.667 units, the utilization of the maximum number of units of both types of materials may be 2901.667 units less than the target value.

Analysis of the Results of Second Model:
The results of the second model show that, when the priorities are switched, the overuse of skilled and unskilled labor and second-type materials is completely minimized, while the overuse of material type 1 is not completely minimized, which is exactly the same as the first model. The number of completed products that are both types of doors may be 2029 units, more like the first model, and the under-achievement of profit for main doors and panel doors has been completely minimized, matching the first model. The second model's results also show that 2901.667 more units of both kinds of materials may be used to make doors and that there is a requirement of 10 units in the event that labor is deployed. Minimization of under run of material cost budget is fully achieved.

Analysis of the Results of Third Model:
It is evident from the third model's analysis that the goals for the number of skilled and unskilled workers involved in door construction as well as the quantity of first-type material units used in door construction have been fully met, with the requirement for an additional 2500 units of second-type material. Similar to the first and second models, the main door and panel door profit targets have been entirely met. The examination of the third model makes it evident that both the labor cost budget and the material cost budget objective have been exceeded. The two overachieved numbers are 5000 and 1491000, respectively.

Analysis of the Results of Fourth Model:
It is clear from the analysis of 4th model that, results of this model are exactly same as 1st model. Values of decision variables of 4th and 1st models are also exactly same.

Table 3:- Summary of the values of decision variables in above mentioned models.

Variables	Models			
	Model 1	Model 2	Model 3	Model 4
x_1^L	99	100	100	99
x_2^L	65	65	65	65

x_1^M	36598.33	36598.33	37000.00	36598.33
x_2^M	18500	18500	21000.00	18500
x^{MD}	10045.45	10045.45	10045.45	10045.45
x^{PD}	8007.368	8007.368	8007.368	8007.368

Table 4:- Summary of analysis of different goals of the models.

Priority	Description and Achievement according of different objectives (goals)			
	Model 1	Model 2	Model 3	Model 4
P_1	Minimize over utilization of skilled labours.	Minimize over utilization of skilled labour.	Minimize over utilization of skilled labours.	Minimize over utilization of skilled labours.
	Under achieved by 1 unit.	Fully achieved.	Fully achieved.	Under achieved by 1 unit.
	Minimize over utilization of unskilled labour.	Minimize over utilization of unskilled labour.	Minimize over utilization of unskilled labour.	Minimize over utilization of unskilled labour.
	Fully achieved.	Fully achieved.	Fully achieved.	Fully achieved.
	Minimize over utilization of material type 1.	Minimize over utilization of material type 1.	Minimize over utilization of material type 1.	Minimize over utilization of material type 1.
	Under achieved by 401.6667 units.	Under achieved by 401.6667 units.	Fully achieved.	Under achieved by 401.6667.
	Minimize over utilization of material type 2.	Minimize over utilization of material type 2.	Minimize over utilization of material type 2.	Minimize over utilization of material type 2.
	Fully achieved.	Fully achieved.	Over achieved by 2500.000 units.	Fully achieved.
P_2	Minimize under achievement of number of finished product.	Minimize under achievement of number finished product.	Minimize under achievement of number of finished product.	Minimize under achievement of number of finished product.
	Over achieved by 2029.033.	Over achieved by 2029.033.	Over achieved by 2939.950 units.	Over achieved by 2029.033 units.
P_3	Minimize overrun of labour cost budget.	Minimize over utilization of maximum no. of units of both types of labours, skilled and unskilled.	Minimize over achievement of the profit for main doors.	Minimize overrun of labour cost budget.
	Under achieved by 85000.00	Under achieved by 10 units.	Fully achieved.	Under achieved by 85000.00.
	Minimize overrun of material cost budget.	Minimize over utilization of maximum no. of units of both types of materials.	Minimize over achievement of the profit for panel doors.	Minimize overrun of material cost budget.
	Fully achieved.	Under achieved by 2901.667 units.	Fully achieved.	Fully achieved.
P_4	Minimize under utilization of maximum no. of units of both types of labours, skilled and unskilled.	Minimize under run of labour cost budget.	Minimize under utilization of maximum no. of units of both types of labours, skilled and unskilled.	Minimize under achievement of the profit for main doors.
	Under achieved by 11 units.	Over achieved by 5000.00	Under achieved by 10 units.	Fully achieved.
	Minimize under	Minimize	Minimize under	Minimize under

	utilization of maximum no. of units of both types of materials.	under run of material cost budget.	utilization of maximum no. of units of both types of materials.	achievement of the profit for panel doors.
	Under achieved by 2901.667 units.	Fully achieved.	Fully achieved.	Fully achieved.
P_5	Minimize under achievement of the profit for main doors.	Minimize under achievement of the profit for main doors.	Minimize under run of labour cost budget.	Minimize under utilization of maximum no. of units of both types of labours, skilled and unskilled.
	Fully achieved.	Fully achieved.	Over achieved by 5000.00	Under achieved by 11 units.
	Minimize under achievement of the profit for panel doors.	Minimize under achievement of the profit for panel doors.	Minimize under run of material cost budget.	Minimize under utilization of maximum no. of units of both types of materials.
	Fully achieved.	Fully achieved.	Over achieved by 1491000.00	Under achieved by 2901.667 units.

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References:-

1. Duangsathaporn, K.; Prasomsin, P. (2005). Application of Linear Programming in Forest: Management Planning for a Forest Plantation, NSTDA Annual Conference.
2. Field, David B. (1973). Goal Programming for Forest Management. Forest Science. 19(2): 125-135.
3. Gomez, T.; Hernandez, M.; Leon, M.A.; Caballeroa, R. (2006). A forest planning problem solved via a linear fractional goal programming model. Forest Ecology and Management. 227: 79–88.
4. Roetter, R.P.; Hoanh, C.T.; Aggarwal, P.K.; Van Keulen, H. (2000). Challenges, Project Strategy and Major Accomplishments. SysNet Research Paper Series No.3, pp.3-10.
5. Sadjadi, S.J.; Arabzadeh, S. (2008). A Multi-Objective Geometric Programming Model for Optimal Production and Marketing Planning. Journal of Industrial Engineering International. 4(7): 33-37.
6. Sen, N.; Nandi, M. (2012). An Optimal Model using Goal Programming for Rubber Wood Door Manufacturing Factory in Tripura. Mathematical Theory and Modeling. 2(8): 31-36.