An Optimal Model using Goal Programming for Rubber Wood Door Manufacturing Factory in Tripura

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Abstract
Rubber plantation requires re-planting after 32 to 34 years when collection of latex becomes uneconomical. For commercial utilization and value addition to those rubber logs felled during re-plantation, processing of Rubber Timber is vital, otherwise of no timber value. Restriction on use of Forestry timber, inspires to setting up of Rubber Wood manufacturing unit. Carpentry unit plays a important role to popularize 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. Rubber Wood Door also has immense export potential. In this study, an attempt has been taken to formulate a strategic planning using the Goal Programming approach. The model formulated for this study may help to set up related manufacturing units.
Keywords: Linear Goal Programming, Priority Level, Optimization.

1.Introduction
The state Tripura has become one of the most thrust areas for Rubber growing because of its well acceptance worldwide. In fact, Tripura was declared the 'Second Rubber Capital of India' after Kerala. In India, rubber is traditionally grown in Kerala, Karnataka, Tamil Nadu and North Eastern Region, mostly in Tripura and Assam. Rubber plantations are a success story in Tripura which is now the 2nd largest rubber growing state with 60% of the potential area under rubber plantation. Rubber is identified as a priority crop for rehabilitation project in Tripura. Rubber plants generally have 32 years of economic life but they may live up to 100 years or even more than that. Rubber plantation requires re-planting after 32 to 34 years when collection of latex becomes non-profitable. For commercial utilization and vale addition to those rubber logs felled during re-plantation, processing of Rubber timber is vital otherwise of no timber value.

Tripura Rubber Industry is one of the largest industries in the northeastern states. The state closely follows Kerala as it heels in rubber production and credited to be the nation's second largest producer of rubber. More and more rubber plantations have mushroomed in the state. Consequently, with the increase in production of rubber, the rubber industry in Tripura has a major industrial enterprise.

The natural rubber industry is one of the principal 'Thrust Sector' in the economy of the state. It is expected that rubber production will generate substantial revenue for the state in the coming years. The Tripura Incentive Scheme is provided a number of beneficial facilities to aid the growth of rubber based industries in the state. Rubber logs has no market value unless it is chemically treated followed by Scientific seasoning. Making of furniture from rubber wood is economically beneficial. Door manufactured from rubber wood has good market in the country and also good export potential. Mainly two types of doors namely Main Door and Panel Door can be made from Rubber wood. Treated Rubber Wood and Solid Rubber Wood Board can be used as starting material for door manufacturing. Such type of industry is economically profitable and also has great impact on economic sector of the state.

2.About Goal Programming and Its Application
Goal Programming (GP) itself by reengineering many of the prior single objective Linear Programming (LP) models with multiple and / or conflicting objectives. Most of methodologies used in LP problem solving that is Simplex method, Duality, Sensitivity analysis can be equivalently converted to solve GP problem with minor revisions to the algorithms. One main characteristics that makes GP model different from LP and other Mathematical Programming is that there is no decision variable in the objective function but replaces deviation variable instead that is GP minimizes deviations from multiple goals subject to constraints. The constraints are goal statements and otherwise that is technological constraints and non-negativity constraints. Although the mathematical structure of goal statements looks exactly the same as LP constraints , they do not perform equivalently to LP constraints. LP constraints are rigid, called rigid constraints or hard constraints, they need to

be satisfied and no violation is allowed while goals perform as soft constraints which accept a certain amount of violation of constraints. Goals are satisfied as close as possible. Thus goal targets may or may not be achieved. Goal Programming model without pre-emptive priority nor weighting is as follow:

$$\text{Minimize} \quad Z = \sum_{i=1}^{m}(d_i^- - d_i^+)$$
$$\text{Subject to} \quad \sum_{j=1}^{n} a_{ij}x_j + d_i^- - d_i^+ = b_i$$
$$i = 1,2,\dots,m$$
$$d_i^-, d_i^+, x_i \geq 0$$

where

$x_i =$ decision variable

$a_{ij} =$ coefficient corresponding to x_j in constraint i

$n =$ number of decision variables

$m =$ number of constraints

and $d_i^- d_i^+ = 0$ for linear GP model

where $d_i^- =$ negative deviation variable from underachievement goal i

$d_i^+ =$ positive deviation variable from overachievement goal i

The first idea of GP techniques is initiated by A. Charnes, W.W.Cooper(1955). The GP was originally proposed for linear programming by Charnes and Cooper in 1961. T.C.Koopmans, H.W.Kuhn and A.W.Tucker discussed Multi-objective Optimization Problem (MOP) in their papers (1951). GP has received substantial and widespread attention since mid-1970s. After that, it is the most widely use multi-criteria decision making (MCDM) technique (Ignizio,1985, Schniederjam,1995; Tamiz 1998). The applications are categorized in many fields, i.e. agriculture, engineering, accounting, finance, marketing, economics, education, health care, government budgeting and international aspects. Shamir, M.J.Beam and A.Galiel formulated GP models in area of coastal land resources (1984).

Remero (1991) presented a comprehensive overview on engineering applications where goal programming technique has been used. Nuray Misir and Mehmet Misir presented a paper where GP was used in developing multi-objective forest management planning model. Forest function considered as forest management objectives (goals) in the model include wood production, soil protection and water production. Diaz-Balterio and Romero in their paper mentioned that the interests of society as a whole should be pursued in Forest management (2001). According to Field, the manager essentially attempts to make a decision that results in solution that comes as possible to reaching all goals (1973). Sinha and Sen developed a GP model in their paper to study the present scenario of tea industry of Barak Valley of Assam (2011).

3.Problem Statement

Due to economic importance of Rubber, the people of Tripura call it “ liquid gold”. Like latex, rubber logs also has economic value if it is scientifically processed. Using rubber timber or word as raw material , small and medium size industries can be planted. Furniture making from rubber wood has huge market nationally as well as internationally. In this paper, our main focus is on door makings using rubber wood. We try to formulate a suitable mathematical model for rubber wood door manufacturing factory. Establishing a new manufacturing plant is not so easy. It faces so many problems. Our motto is to minimize the odds as much as possible.

4.Model Formulation

To formulate a GP model, the symbols used and model components i.e. goal constraints and achievement function are explained.

Goal 1: Labor Constraints:

The plant must have a minimum of b_1^L units of skilled labor, x_1^L and b_2^L units of unskilled labor, x_2^L, in order to operate economically. The maximum number of units of labor that can be used in the plant is b^L.

Therefore $$x_1^L + d_1^{L-} - d_1^{L+} = b_1^L$$

$$x_2^L + d_2^{L-} - d_2^{L+} = b_2^L$$

$$x_1^L + x_2^L + d_3^{L-} - d_3^{L+} = b^L$$

Goal 2: Material Constraints:

The making of rubber wood door that is produced at the plant requires two types of major raw materials----- Solid Wood Board and Treated Timber. The minimum usage of the first type material x_1^M is b_1^M units per year and the minimum usage of the second type material x_2^M is b_2^M units per year. The maximum number of units of material that can be utilized in the plant is b^M units.

$$x_1^M + d_1^{M-} - d_1^{M+} = b_1^M$$

$$x_2^M + d_2^{M-} - d_2^{M+} = b_2^M$$

$$x_1^M + x_2^M + d_3^{M-} - d_3^{M+} = b^M$$

Goal 3: Required production constraints:

The plant is expected to generate maximum number of units of finished product per year. If it takes c_1^{FL} units of x_1^L, c_2^{FL} units of x_1^L, c_1^{FM} units of x_1^M, c_2^{FM}units of x_2^M to make one unit of finished product (FP) then

$$c_1^{FL}x_1^L + c_2^{FL}x_2^L + c_1^{FM}x_1^M + c_2^{FM}x_2^M + d_1^{FP-}d_1^{FP+} = b^{FP}$$

Goal 4: Budget Constraints:

To achieve the minimum cost per unit for labor and materials, we have

$$c_1^L x_1^L + c_2^L x_2^L + d_4^{L-} - d_4^{L+} = b^{BL}$$

$$c_1^M x_1^M + c_2^M x_2^M + d_4^{M-} - d_4^{M+} = b^{BM}$$

Goal 5: Profit Constraints:

Mainly two types of product--- main doors and panel doors are produced in the factory. To achieve the maximum profit per unit of main door and panel door per year, we have

$$c^{MD}x^{MD} + d_1^{MD-} - d_1^{MD+} = b^{MD}$$

$$c^{PD}x^{PD} + d_1^{PD-} - d_1^{PD+} = b^{PD}$$

Priorities of goals:

Goal	Priority
Labor, Material, Finished Product	P_1
Budgeted allocation for labor	P_2
Budgeted allocation for material	P_3
Profit	P_4

Achievement function:

Minimize

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

Explanations:

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.

Constants

$b_1^L =$ Minimum no. of units of skilled labor.

$b_2^L =$ Minimum no. of units of unskilled labor.

$b_1^M =$ 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 labors.

$b^M =$ 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.

$c_2^L =$ Cost per unit for unskilled labor.

$c_1^M =$ 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 labor.

$c_2^{FL} =$ Units of x_2^L unskilled labor.

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 structure of the GP model will be expressed as

Minimize

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

Subject to goal constraints

$$x_1^L + d_1^{L-} - d_1^{L+} = b_1^L$$

$$x_2^L + d_2^{L-} - d_2^{L+} = b_2^L$$

$$x_1^L + x_2^L + d_3^{L-} - d_3^{L+} = b^L$$

$$x_1^M + d_1^{M-} - d_1^{M+} = b_1^M$$

$$x_2^M + d_2^{M-} - d_2^{M+} = b_2^M$$

$$x_1^M + x_2^M + d_3^{M-} - d_3^{M+} = b^M$$

$$c_1^{FL} x_1^L + c_2^{FL} x_2^L + c_1^{FM} x_1^M + c_2^{FM} x_2^M + d_1^{FP-} d_1^{FP+} = b^{FP}$$

$$c_1^L x_1^L + c_2^L x_2^L + d_4^{L-} - d_4^{L+} = b^{BL}$$

$$c_1^M x_1^M + c_2^M x_2^M + d_4^{M-} - d_4^{M+} = b^{BM}$$

$$c^{MD} x^{MD} + d_1^{MD-} - d_1^{MD+} = b^{MD}$$

$$c^{PD} x^{PD} + d_1^{PD-} - d_1^{PD+} = b^{PD}$$

5.Solution of the Formulated Model

On the basis of available data, the developed model can be tested. Solution may be achieved by manual calculation. But manual calculation is time consuming process and not so easy. So the use of software like LINGO, Excel-Solver will be more easy.

6.Conclusion

Rubber Industries in Tripura has various sectors. In this paper, we only consider the door manufacturing factory. The factors which are essential for the model are considered. Our study can be applied to other industries having the similar environmental constraints.

References

Atis, E., Nurlu, E. and Kenaroglu, Z.(2005). Economic and Ecological Factors Affecting Sustainable Use of Agricultural Land and Optimal Sustainable Farm Plans: The Case of Menemen. Pakistan Journal of Biological Sciences, 8(1), 54-60.

Bell, Enoch F. (1976).mGoal Programming for Land Use Planning, USDA Forest Service General Technical Report, PNW-53. U.S. Department of Agriculture, USA.

Diaz-Balterio, L. and Romero, C. (1998). Modeling Timber Harvest Scheduling Problems With Multiple Criteria: An Application In Spain, Forest Science, 44, 47-57.

Field, David B. (1973). Goal Programming for Forest Management. Forest Science, 19(2), 125-135.

Glynm, Joseph G. (2005). A Goal Programming Approach to Human Resource Planning with a Concentration on Promotion Policy, Journal of Business & Economic Research, 3(3), 71-80.

Gordon, G., Pressman, I. and Cohn, S. (1990). Quantitative Decision Making for Business, Prentice Hall, USA.

Ignizio, J.P. (1976). Goal Programming and Extensions, Lexington, MA: Lexington Books.

Jafari, H., Koshteli, Q.R. and Khabiri, B. (2008). An Optimal Model Using Goal Programming For Rice Farm. Applied Mathematical Science, 2 (23),1131-1136.

Kwak, N.K. and Schniederjans, M.J. (1985). A Goal Programming Model as an Aid in Facility Location Analysis. compute & Opt. Res. 12(2),151-161.

Misir, N. and Misir, M. (2007). Developing A Multi-Objective Forest Planning Process With Goal Programming: A Case Study. Pakistan Journal of Biological Sciences, 10(3),514-522.

Nja, M.E. and Udofia, G.A. (2009). Formulation of the Mixed-Integer Goal Programming Model for Flour Producing Companies. Asian Journal of Mathematics and Statistics, 2(3), 55-64.

Pal, B.B. and Basu, I. (1996). Selection of Appropriate Priority Structure for Optimal Land Allocation In Agricultural Planning Through Goal Programming. Indian Journal of Agricultural Economics, 51, 342-354.

Pongthanapanich, T. (2003). Review of Mathematical Programming for Coastal Land Use Optimization.

Rustagi, K. (1973). Forest Management Planning for Timber Production: A Goal Programming Approach, Yale Unvi.

Sen, C. (1983). A New Approach for Multi-Objective Rural Development Planning, The Indian Economy Journal, Vol.30, No.4.

Sinha, B. and Sen, N. (2011). Goal Programming Approach to Tea Industry of Barak Valley of Assam. Applied Mathematical Sciences, 5(29),1409-1419.

Tamiz, M., Jones, D. and Romero, C. (1998). Goal Programming for Decision Making: An overview of the current state-of-the art. Europe Journal of Operation Research, 111, 569-581.