Goal Programming Approach to Tea Industry of Barak Valley of Assam

Banashri Sinha
Department of Mathematics
Assam University, Silchar, India, Pin-788011
Email:sinha.banashri@gmail.com

Nabendu Sen
Department of Mathematics
Assam University, Silchar, India, Pin-788011
Email:nsen_16@yahoo.co.in

Abstract

The tea industries of Barak Valley, a region of Assam plays a vital role for the development of the region. It not only provides employment to the thousands of people of this valley but also the main source of income for this valley. But for the poor strategies made by the management of tea industries, it is not flourishing in a way it is desired to be. So in this study an attempt has been taken to formulate a strategic planning using the Goal Programming approach. A brief history of tea industries of Assam and Barak Valley has been depicted. The paper presents six different plans of Goal Programming approach, which were considered for the maximization of production quantity of made tea, profit and demand and minimization of expenditure and processing time in different machines. The goals are identified and prioritized. A review on Goal programming and its growth and application in various industrial sectors are discussed. The model presented in this study is hopefully will have general appeal to planners in the agro-based industries facing similar problems.

Mathematical Subject Classification: 90C29

Keywords: Linear goal programming, Priority, optimization etc.
1. Introduction

Assam is the second commercial tea production region after southern China. Assam is one of the only two regions in the world with native tea plants. The development of tea industry in Assam is the legacy of British administration. The British’s adventure to develop tea plantation in Assam dates back to 1823. The tea plant was first discovered in Assam in 1823 by Robert Bruce; the merchant and soldier of East India Company. Subsequently, tea nurseries were developed by the Govt. in upper Assam and the first tea garden was started at Chabua in Dibrugarh district in 1837.

Barak valley, a geographical territory situated in the southern part of Assam, is full of green tea gardens. Tea cultivation is an indispensable part of the cultural heritage of this land. The tea plantation in the Barak Valley (earlier Surma Valley during British period) was taken up after the annexation of Cachar in 1832. It is reported that for the first time tea gardens in Barak Valley were started in 1855 at Bursangaon and Gungurpar. Subsequently it was developed in Kathal, Silcoorie and Arcattipore and in many other places near Silchar. By the first quarter of the 20th century as many as 100 gardens were established in Barak Valley. During the nineteenth century, Cachar tea was holding the top position in production among the districts of Assam but since then the balance dramatically reversed. The climate and soil conditions are often cited as the reason but the historical evidences of tea cultivation in Assam in its initial stage (i.e., mid 19th century) do not substantiate such arguments. According to the recent statistics, this valley has 112 tea gardens, out of which 6 are sick and remaining are producing green leaves and made tea.

Sen [1] studied on sick tea industries of Barak Valley and observed that the causes of sickness in the tea estates of Barak Valley are ‘mismanagement’ and ‘less investment’ as the two principal factors. These two factors happen to be the main causes of sickness in 70% of the sick gardens in Barak Valley. Deb [12] formulated a transportation schedule for minimization of transportation cost of tea industries of this valley. After that no effort has been given to make mathematical study in this regards.

2. Overview of Goal Programming

The paradigm of multiple criterion decision aid processes remains in the fact that the decision makers consider in their decisions many factors of quite diversified nature and therefore do not optimize only one single objective. Practically this is expressed by searching the most satisfying compromise among the several objectives which are often conflicting [6].

One of the most promising techniques for multiple objective decision analysis is Goal Programming. Goal Programming is a powerful tool which draws upon the highly developed and tested techniques of Linear Programming, but provides a
simultaneous solution to a complex system of competing objectives. Goal Programming can handle decision problems having a single goal with multiple subgoals [21].

It was first introduced by Charnes et al. in 1955[2], more explicitly defined by the same authors in 1961[3], and further developed by Ijiri [25] during the 1960’s. The first book dedicated to Goal Programming by Lee[21] and Ignijio[9] appeared during the early to mid 1970’s.

In Goal Programming, instead of attempting to maximize or minimize the objective function directly as in the Linear Programming, the deviations between goals and what can be achieved within the given set of constraints are minimized. In the simplex algorithms of Linear Programming such deviations are called slack variables. These variables take a new significance in Goal Programming. The deviational variable is represented in two dimensions, both the positive and the negative deviations from each goal or subgoal. Then the achievement function becomes minimization of these deviations based on the relative importance or priority assigned to them.

The general goal programming model can be mathematically expressed as:

Minimize $Z = d^- + d^+$  

Subjected to $f(x) + d^- - d^+ = g_1$ and $\sum\limits_{j=1}^{n} a_{ij} * X_j \leq b_i$, $i = 1, 2, \ldots, m$; $X_j \geq 0$, $d^- \geq 0, d^+ \geq 0$

Here $g_1$ is the goal which is expected from the objective functions

$f(x) = \sum\limits_{j=1}^{n} C_j X_j = CX$ to achieve as closely as possible subject to the given constraints.

3. Review on Goal Programming and Its Application

The application of Goal programming in the solution of problems affecting production management was studied by different researchers. Shim and Siegel[10] developed Goal programming model with sensitivity analysis to determine the decision variable and goal deviations. Cobb and Warner[19], Trivedi[23] used mixed integer Goal programming model for resource allocation in order to solve management related problems for quality service. Thierauf et al[20] also employed mixed integer Goal programming model for the solution of problems associated with production planning. Kumar et al [13] formulated mixed integer Goal programming model for vendor selection in which three different goals indicated.
Nja and Udofia[14] formulated Goal programming model for flour producing companies. Their model was based on production time of three different products. Kwak and Lee[17] developed goal programming model for human resources allocation in a health-care organization. In their study, they tried to minimize payroll cost with patient’s satisfaction. Also the attempt has been made for the proper allocation of three different categories of staffs in three different departments. They considered five different goals and three structural constraints in their investigation.

Vivekandan et al[18] used goal programming for the optimization of cropping pattern for a particular region. In their study they concentrated mainly on the factors net return and proper utilization of surface and ground water in irrigated agriculture and different plans were formulated. In their work it can be found that the average water utilized by 1st plan was considerably less than the other two plans and also it has been observed that the maximum return was for 1st plan out of three plans.

Alade et al[11] developed a multi-objective model for the planning of developing countries. In their model, they examined industrial structure, labour force, value added in export, capital efficiency, imported inputs for exports, investment planning etc and it was applied for Indian economy. Stewart[22] studied the essentiality of multi-objectivity of linear programming. We find the application of goal programming model for standard flow-shop scheduling problem by Selen and Hott[24].

Anderson and Earle[5] used goal programming for diet planning in the 3rd world. Later their study was restudied by Romero and Rehman[7]. Jafari et al[8] formulated goal programming model for rice farm. In their study, the lexicographic goal programming model was considered to identify the optimal compound of agricultural product in the rice farm land of a village of Bebol county. Ortuno and Vitoriano[15], by using goal programming approach tried to schedule the task to reduce the cost involved. In their work 0-1 programming model was prepared to attain the proposed objective, moreover the goal programming were used to model time windows in a more flexible ways. Gupta and Evans[4] in their work for the operation of closed-loop supply chains developed goal programming model. The results of the analysis were carried out by them shows that both the effects of varying the priorities or weight associated with the goal and how the values of the deviational variables can aid a decision maker. Mezghani et al [16] proposed a Goal programming model to study Aggregate production planning problem by considering manager’s preferences.

4. PROBLEM STATEMENT

Barak valley is a part of Assam, full of tea gardens producing green leafs as well as made tea in different grades. These teas are C.T.C. type. The management of leading tea gardens has their preferences to get a handsome return. Also, at the same time, the management of concerned tea gardens does not want to
compromise with the interest of its employees. The total production, total profit, total expenditure, fulfillment of demand of various grades of tea etc are main objective. Moreover, the management wants to meet the expected demand of various grades of tea in the markets. Also the overtime is not desirable but it can be allowed if the demand is more. With these considerations, the concerned tea industry wants to make a plan. The objectives are of different attribute and conflicting in nature, a mathematical model which can meet the objectives is desired to be developed in a gainful way for the management of tea gardens. The stages of the processing through which green tea leaves are passed also described as:

1\(^{st}\) Stage: In this stage, evaporation of moisture content in the tea leaf is done which is known as withering.

2\(^{nd}\) Stage: This stage consists of the process; cutting of tea leaves in different ways:
(a) Pieces of leaves are made using the machine roller vane or BLC.
(b) The machine C.T.C is used for cutting, twisting and curling.
(c) The machine Rottery is used to make the granular form.

3\(^{rd}\) Stage: After the cutting process, the made tea is gone through fermentation using the machine CFM and Floor fermentry.

4\(^{th}\) Stage: After fermentation process, drying of the fermented tea are done using the dryer.

5\(^{th}\) Stage: Now after the drying, sorting or grading according to size of tea is done through Vibrosorter.

6\(^{th}\) Stage: After all the processing, made tea are sent for packaging(swing and marking).

Also the total budget for the process, machine availability and the space for storing the packaged tea are mentioned by the management according to their efficiency.

5. GP Model Development

To develop a GP model, the symbols used and the model components (system constraint, goal constraint and achievement function) are explained below:

**SYSTEM (NON-GOAL) CONSTRAINTS:**

i) Budget allocation:

The total amount available for the total expenditure is limited for each month, which can be given by

\[ \sum_{i=1}^{6} \chi_i x_i \leq \chi \]

ii) Availability of machines:

Up to the 4\(^{th}\) stage of processing of tea production from green leaves are same but it changes at 5\(^{th}\) and 6\(^{th}\) stage so if we consider the machines used in the 5\(^{th}\) and 6\(^{th}\) stage as machine 1 and machine 2, we can
construct the constraints on the limitation of availability of machines
and these can be expressed as,
\[
\sum_{i=1}^{5} t_{1i}x_i \leq \beta_1
\]
\[
\sum_{i=1}^{5} t_{2i}x_i \leq \beta_2
\]

iii) Inventory Space constraints:

Let \( A_i \) denote the area occupied by 25 units (say) by each \( i \)-th grade of tea. Here we consider 25 units as a unit. Then after the whole processing, it will be necessary to store the packaged tea before dispatching so the inventory space constraint is developed and can be expressed as
\[
\sum_{i=1}^{5} A_i x_i \leq A
\]

GOAL CONSTRAINTS:

P_1: Production goal (per month)

The most important goal of the present study is to achieve the maximum of tea production of various tea grades from the tea garden. After considering the total quantity per month from the tea garden, the goal constraint can be expressed as
\[
\sum_{i=1}^{5} x_i + d_{1i}^- - d_{1i}^+ = \beta_3
\]

P_2: Profit goal (per month)

To achieve the maximum profit per month from different grades of made tea the constraint can be expressed as
\[
\sum_{i=1}^{5} \alpha_i x_i + d_{2i}^- - d_{2i}^+ = \alpha
\]

P_3: Production expenditure goal (per month)

To achieve the minimum of expenditure in production of the tea garden per month the goal constraint can be expressed as
\[
\sum_{i=1}^{5} \gamma_i x_i + d_{3i}^- - d_{3i}^+ = \gamma
\]

P_4: Demand goal (per month)

To meet the expected demand of the market of the various tea grades, the constraint can be stated as:
\[
\sum_{i=1}^{5} \xi_i x_i + d_{4i}^- - d_{4i}^+ = \beta_4
\]

P_5: Processing time (of machines) goal

To avoid the over-utilization of processing time i.e., to avoid the overtime, in the machines. We can express the constraints in machine 1 and machine 2 as
Goal programming approach

\[
\sum_{i=1}^{5} t_i x_i + d^5_i - d^5_i = \beta_5 \\
\sum_{i=1}^{5} t_i x_i + d^6_i - d^6_i = \beta_6
\]

Where \( P_i \) are the priorities set and defined as \( P_i > P_{i+1} \).

Achievement Function:
Minimize \( Z = P_1 d_1^- + P_2 d_2^- + P_3 d_3^- + P_4 d_4^- + P_5 (d_5^- + d_5^+) \)

NOTATION AND SYMBOLS:
\( x_i \) = The quantity of different grades of made tea according to the size ‘i’
\( X_i = 25 \) units of \( x_i \) packed together.
\( \alpha_i \) = The profit per month (in Rs.) per unit quantity of made tea.
\( \gamma_i \) = The production expenditure per unit weight per month (in Rs.)
\( \xi_i \) = The percentage of demand of total quantity of ‘i’ th grade.
\( t_{ij} \) = Time needed per unit of \( i \)-th grade in the \( j \)-th machine.
\( d_i^- \) = under achievement of goals or constraints.
\( d_i^+ \) = over achievement of goals or constraints.
\( \chi_i \) = The total budget of i-th grade tea available per unit weight per month.
\( i \) = the grade of tea depending upon the size = 1, 2, 3, 4, 5.
\( j \) = the machine in use = 1, 2.
\( \alpha \) = The desired total profit of made tea produced per month.
\( \gamma \) = The limit of production expenditure per month.
\( \chi \) = The total budget available for the whole process per month.
\( A \) = The area specified for storage of packaged made tea.
\( \beta_1 \) = The available processing time in machine 1 per month.
\( \beta_2 \) = The available processing time in machine 2 per month.
\( \beta_3 \) = The desired quantity of made tea produced per month.
\( \beta_4 \) = The expected demand of markets per month.
\( \beta_5 \) = The desired processing time in machine 1 per month.
\( \beta_6 \) = The desired processing time in machine 2 per month.
6. Solution of the Developed model

The developed model can be validated with the data available from respective tea industry. Moreover the manual calculation for the solution to the model may not be very easy. So the use of software like LINGO, Micro management Software etc will be of immense help.

7. Conclusion

The model has been developed by considering the environmental conditions of tea industries of Barak valley of Assam (India). The priority of different goals in this study has been given by considering the view of Manager’s opinion. The study will be better if we rearrange the ranking of priority from author’s side and the present work can be extended to the new direction. Moreover the introduction of other constraints (goal as well as structural) in the present model will improve it for better solution. Our study can be applied to other industries having the similar environmental constraints.

Appendix

Achievement Function:

Minimize \( Z = P_1d_1^- + P_2d_2^- + P_3d_3^+ + P_4d_4^- + P_5(d_5^+ + d_6^-) \).

Subject to,

System Constraints:

\( x_i + x_2 + x_3 + x_4 + x_5 + d_1^- - d_1^+ = \beta_3 \)

\( \alpha_1x_i + \alpha_2x_2 + \alpha_3x_3 + \alpha_4x_4 + \alpha_5x_5 + d_2^- - d_2^+ = \alpha \)

\( \gamma_1x_1 + \gamma_2x_2 + \gamma_3x_3 + \gamma_4x_4 + \gamma_5x_5 + d_3^- - d_3^+ = \gamma \)

\( \xi_1x_1 + \xi_2x_2 + \xi_3x_3 + \xi_4x_4 + \xi_5x_5 + d_4^- - d_4^+ = \xi_4 \)

\( t_{11}x_1 + t_{12}x_2 + t_{13}x_3 + t_{14}x_4 + t_{15}x_5 = \beta_1 \)

\( t_{21}x_1 + t_{22}x_2 + t_{23}x_3 + t_{24}x_4 + t_{25}x_5 = \beta_2 \)

\( A_1x_1 + A_2x_2 + A_3x_3 + A_4x_4 + A_5x_5 = A \)

Goal Constraints:

\( \alpha_1x_i + \alpha_2x_2 + \alpha_3x_3 + \alpha_4x_4 + \alpha_5x_5 + d_2^- - d_2^+ = \alpha \)

\( \gamma_1x_1 + \gamma_2x_2 + \gamma_3x_3 + \gamma_4x_4 + \gamma_5x_5 + d_3^- - d_3^+ = \gamma \)

\( \xi_1x_1 + \xi_2x_2 + \xi_3x_3 + \xi_4x_4 + \xi_5x_5 + d_4^- - d_4^+ = \xi_4 \)

\( t_{11}x_1 + t_{12}x_2 + t_{13}x_3 + t_{14}x_4 + t_{15}x_5 = \beta_1 \)

\( t_{21}x_1 + t_{22}x_2 + t_{23}x_3 + t_{24}x_4 + t_{25}x_5 = \beta_2 \)

\( A_1x_1 + A_2x_2 + A_3x_3 + A_4x_4 + A_5x_5 = A \)
Where $x_i$'s $\geq 0$, $t_i$'s $\geq 0$ and $d_i^+$'s $\geq 0$, $d_i^-$'s $\geq 0$ with the condition $d_i^+, d_i^- = 0$

Acknowledgement: Authors are thankful to Dr. U.S. Chakraborty, Department of Mathematics, Assam University, Silchar for constant moral and academic support.

References


Goal programming approach


Received: October, 2010