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Goal Programming, its Application in Management Sectors– Special Attention into Plantation Management: A Review

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Abstract- Real world problems are mainly based on multiple objectives rather than single objective. Today, in management sectors, most of the producers are more concerned about their own sense than the economical issues. It is necessary for all the managers to do their best to make as much effort as possible to increase the products. It is obvious that one of the ways is to apply mathematical programming model for the management systems. Economical plans are a key in management, applying fundamental programming methods is inevitable. Application of a multi-objective programming model like goal programming model is an important tool for studying various aspects of management systems.

Index Terms- Multi-objective programming, Goal programming, management systems, plantation management

I. INTRODUCTION

Linear Programming technique is applicable only in the situation of single objective such as minimization of cost or maximization of profit. However, in practice, organizational objectives may vary depending upon the characteristics and philosophy of organization, statutory regulations, environmental conditions, etc. though profit maximization is regarded as the sole objective of the management, but due to the pressure of the society and statutory regulations, the management(firm) will have a set of multiple objectives, such as employment stability, high product quality, social contributions, industrial and labour relations, maximization of profit, etc. In order to optimize multiple objectives or goals, a different kind of technique is needed to study and to understand the management system. This technique is known as Goal Programming technique for decision making which is an extension of Linear Programming technique.

II. GOAL PROGRAMMING

The goal programming (GP) technique has become a widely used approach in Operations Research (OR). GP model and its variants have been applied to solve large-scale multi-criteria decision-making problems. The GP technique was first used by Charnes and Cooper in 1960s. This solution approach has been extended by Ijiri (1965), Lee (1972), and others. The Goal Programming Method is an improved method for solving multi-objective problems. Goal programming is one of the model which have been developed to deal with the multiple objectives decision-making problems. This model allows taking into account simultaneously many objectives while the decision-making is seeking the best solution from among a set of feasible solutions. The goal programming technique is an analytical framework that a decision maker can use to provide optimal solutions to multiple and conflicting objectives. Goal programming is a special type of technique. This technique uses the simplex method for finding optimum solution of a single dimensional or multi-dimensional objective function with a given set of constraints which are expressed in linear form. In goal programming technique, all management goals, where one or many, are incorporated into the objective function and only the environmental conditions, i.e.; those outside the management's control are treated as constraints. Moreover, each goal is set at a satisfying level which may not necessarily be the best obtainable, but one that management would be satisfied to achieve given multiple and sometimes conflicting goals. The computational procedure in goal programming is to select a set of solutions which satisfies the environmental constraints and providing a satisfactory goal, ranked in priority order. Low ordered goals are considered only after the higher ordered goals are satisfied. If ordinal rankings of goals can be provided in terms of importance or contributions and all goal constraints are linear in nature, the solution of the portion can be obtained through Goal Programming. In solution of LGP models, performed to minimize the deviation of determined target according to priority and weight coefficients defined by decision maker's are carried. Goal programming method is not only a technique to minimize the sum of all deviations, but also a technique to minimize priority deviations as much as possible. The results of multi-objective problem solutions are affected by the decision of the manager or decision maker. Therefore, when there is a concession between goals, there will be deviations according to the decisions made. The direction and extent of these deviations play important roles in this type of problem.

In our opinion, goal programming is still to be one of the stronger methods available. It has a close correspondence with decision-making in practice. Furthermore, it has some attractive technical properties. Several empirical findings from decision-making practice are, in our opinion, rather convincing to demonstrate the practical usefulness of multiple goal programming. As mentioned by several writers, the method corresponds fairly well to the results of the behavioural theory of the firm. In practice, decision-makers are aiming at various goals, formulated as aspiration levels. The intensity with which the goals are strived for may vary from goal to goal; in other words, different 'weights' may be assigned to different goals. The use of

aspiration levels in decision-making is also reported by scientists from other fields, like for instance psychology. In the same way, also pre-emptive priorities are known in real life problems. Support for this in fact lexicographic viewpoint is provided by Fishburn (1974) and Monarchi et al (l976). A more concrete example of the correspondence of multiple goal programming and practice is provided by Ijiri (1965), who views multiple goal programming as an extension of break-even analysis, which is widely used in business practice. The above plea for multiple goal programming is of a so roe what theoretical nature. Of course, the operational usefulness of multiple goal programming can only be shown in practice. Although it is a relatively 'young' method, many applications have been reported in literature. To give an idea, we have listed some of these applications, especially in the field of business and managerial economics (Nijkamp and Spronk 1977). One of the technical advantages of multiple goal programming is that there .is always a solution to the problem, even if some goals are conflicting, provided that the feasible region R is non-empty. This is due to the inclusion of the deviational variables y. and y. . These variables show whether the goals are attained or not, and in the latter case they measure the distance between the realized and aspired goal levels. Another advantage of multiple goal programming is that it does not require very sophisticated solution procedures. Especially the linear goal programming problems can be solved by easily available linear programming routines. An important drawback of multiple goal programming is its need for fairly detailed a priori information on the decision-maker's preferences.

Goal programming is used to manage a set of conflict objectives by minimizing the deviations between the target values and the realized results (Rifai 1994). The original objectives are re-formulated as a set of constraints with target values and two auxiliary variables. Two auxiliary variables are called positive deviation d^+ and negative deviation d^-, which represent the distance from this target value. The objective of goal programming is to minimize the deviations hierarchically so that the goals of primary importance receive first priority attention, those of second importance receive second-priority attention, and so forth. Then, the goals of first priority are minimized in the first phase. Using the obtained feasible solution result in the phrase, the goals of second priority are minimized, and so on. The explicit definition of goal programming was given by Charnes and Cooper (1961).

Goal programming is one of the oldest multi criteria decision making techniques aiming at optimizing several goals and at the same time minimize the deviation for each of the objectives from the desired target. The concept of goal programming evolved as a result of unsolvable linear programming problems and the occurrence of the conflicting multiple objectives goal. Multiple objectives arise in production companies because of several departments with different functions, In fact the basic concept of goal programming is whether goals are attainable or not, an objective may be started in which optimization gives a result which come as close as possible to the indicated goals. The objective of goal programming is to minimize the achievement of each actual goal level. If non achievement is minimized to zero, the exact attainment of the goal has ken accomplished. For a single goal problem, the formulation and solution is similar to linear programming with one exception. The exception is that if complete goal attainment is not possible goal programming will provide a solution and information to the decision makers.

In problem with more than one goal, the manager must rank the goals in order of importance. The procedure is to minimize the deviational variables of the highest priority goal and proceed to the next lower goal. Deviation from this goal is then minimized, the other goals are considered in order of priority but lower order goals are only achieved as long as they do not distract from the attainment of the higher priority god. In order to minimize either underachievement or overachievement of a particular goal, a variable called a" deviational variable" is assigned to the goal. This variable represents the magnitude by which the goal level is not achieved. If the value of the deviational variable is small, the goal is more nearly achieved than if the value is relatively large i.e. optimality occur when deviational variables of the different goals have been minimized to the smallest possible value in order of importance. In general the principle idea of goal programming is to convert original multiple objective into a single goal. The resulting model yields what is usually called an efficient solution because it may not be optimum with respect to all the conflicting objectives of the problem. There are two algorithms for solving goal programming problems. Both methods convert the multiple goals into a single & objective confliction. In the weights methods, the single objective function is the weighted sum of the conflictions representing the goals of the problems, that is, it considers all goals simultaneously within a composite objective confliction, comprising the sum of all respective deviations of the goals from their aspiration levels. The deviations are then weighted according to the relative importance of each goal. To avoid the possible bias effect of the solution to different measurement unit goal, normalization takes place (i.e. the model minimizes the sum of the deviations from the target). The pre-emptive method starts by prioritizing the goals in order of importance. i.e. it is based on the logic that in some decision making sperms, some goals seems to prevail. The procedures begin with comparing all the alternatives with respect to the higher priority goals and continue with the next priories until only one alternative is left. The mode! is then optimized using one goal. at a time such that the optimum value of a higher priority goal is never deemed by a lower priority goal. The two methods do not generally produce the same solution and neither is one method, however, superior to the other because each technique is designed to satisfy certain decision makers' preferences.

III. GOAL PROGRAMMING MODEL

A model is a simplified representation of a real system and phenomenon. It is a formal description of a real system. Models are mere abstractions revealing the features that are relevant to the real system behaviour under study. The nature of models that are appropriate for management decision and planning is such that can be used to represent for example production planning problems. The type of model that can be appropriate for management will include model that can be used to represent management plans in numeric or algebraic forms. The model is commonly used with the intention to gain insight into the general nature of a particular problem in terms of what particular factor

is responsible and how. However, there are a number of purposes for which a model can be constructed.

The multi-objective models in the context of manufacturing were formulated and solved in recent past to provide information on the trade off among multi-objectives. However, although it represents a viable approach to production plaguing, MOGP is not as widespread among manufacturing companies as desired. The modelling approach of goal programming does not maximize or minimize the objective function directly as in Linear Programming but seeks to minimize the deviations (both positive and negative) between the desired goals and then results obtained according to priorities.

The general goal programming formulation considered for n variables, m constraints and k-pre-emptive priority levels is

Min $P_1(w_{i1}^- d_{i1}^- + w_{i1}^+ d_{i1}^+)$; for $i = 1,2,\dots,m$

Min $P_2(w_{i2}^- d_{i2}^- + w_{i2}^+ d_{i2}^+)$; for $i = 1,2,\dots,m$

$\vdots$

$\vdots$

$\vdots$

Min $P_k(w_{ik}^- d_{ik}^- + w_{ik}^+ d_{ik}^+)$; for $i = 1,2,\dots,m$

Subject to $\sum_{j=1}^{n} a_{ij}x_j + d_i^- - d_i^+ = b_i$ for $i = 1,2,\dots,m$

$x_j , d_i^- , d_i^+ \geq 0$

$P_1 \ggg P_2 \ggg \cdots\cdots \ggg P_k$

IV. SURVEY

A lot of research has been carried out in the applications of goal programming in different fields. So we review some of the scholarly work done in this area. Mathematical programming (MP) models for proper allocation of cultivable land to cropping plan have been studied in Heady (1954). From the mid-1960s to 1980s, the different linear programming (LP) approaches to agricultural planning problems have been surveyed by Glen (1987). Although, LP models have been successfully used to the farm planning problems, there is a difficulty to implement them for meeting the different socio-economic goals due to the limitation of optimizing only a single-objective associated with the LP methods developed so far in the farm planning context. Since, most of the cropping plan problems are multi-objective in nature, the goal programming (GP) (Ignizio 1976) as a robust tool for multi-objective decision analysis has been successfully implemented to different farm planning problems. Kenneth et al. (1975) presented a GP model that allowed for multiple, conflicting goals in natural resource allocation management's decision problems. Results were provided for a management area in mountainous Colorado state forest located in northern Colorado. The trade-offs between goal were demonstrated by comparison of results from multiple runs in which the order of goal preferences varied. GP was shown to be a very flexible decision-aiding tool, which can handle any decision problem formulated by linear programming more efficiently. The goal programming combined the logic of optimization in mathematical programming with the decision makers desire to satisfy several goals. Premchandra(1993**)** developed a goal programming model for solving problem of making project decisions that involved a large number of interrelated activities-the planning and scheduling project management. These problems arose in areas such as product development, production planning and controlling and setting up of production facilities. He found that the solution obtained from using Linear Programming (LP) in deciding the optimal crash plan to complete the project within the desired time period was not effective and showed that a goal programming approach can be used efficiently in such decision-making problems. Anderle et al. (1994) applied multiple objective goal programming techniques in management of the Mark Twain National Forest in Missouri;. Accurate market values were not available for some forest products (e.g. dispersed) and therefore, instead of exact coefficients, their approximations (Fuzzy numbers) were dealt with in the modeling phase. The applicability of fuzzy multiple objective programming techniques for resource allocation problems in forest planning were demonstrated. Springer (1995) presented a review of current literature on the branch of multi-criteria modeling known as goal programming. The result of the investigations of the two main goal programming methods, lexicographic and weighted goal programming together with their distinct application areas were reported. Some guidelines to the scope of goal programming as an application tool were given and methods of determining which problem areas were best suited to the different goal programming approaches were proposed. The correlation between the methods of assigning weights and priorities and the standard of the results were also ascertained. Ertugrul et al. (2002) presented a combined analytic network process (ANP) and a zero one goal programming (ZOGP) approach in product planning in quality function deployment (QFD) to incorporate customers' needs and the product technical requirements (PTRs) systematically into the product design phase. Numerical examples were presented to illustrate the application of the decision approach. It considered the interdependence between the customers' needs and PTRs and inner dependence within themselves, along with the resource limitations.

The ZOGP model was constructed to determine the set of PTRs that would take into account in the product design phase considering resource limitations and multi-objective nature of the problem (important levels of product technical requirement using ANP, cost budget, extendibility level and manufacturability level goals). The ZOGP model provided feasible and more consistent solution. Taylor et al. (2003) developed a multi-objective model to solve the production planning problems fix multinational lingerie company in Hong Kong, in which the profit is maximized but production penalties resulting from the going over / under quotas and the change in workforce levels were minimized. Different managerial production loading plans were evaluated according to changes in future policy and situation in order to enhance the practical implications of the model. The multi-site production planning problems considered the production loading plans among manufacturing factories subject

to certain restrictions, such as production import/ export quotas imposed by regulatory requirement of different nations, the use of manufacturing factories / locations with regard to customers' preferences, as well as production capacity, workforce level, storage space and resource conditions of the factories. Adejobi et al. (2003) applied a linear goal programming technique to model the farm-family crop production enterprise in the Savannah zone of Nigeria and developed an optimal crop combination that would enable the small holder farmers meet their most important goals of providing food for the family throughout the year. Latinopoulos et al. (2005) created, applied and evaluated a GP model that aimed at simultaneous maximization of farmer's welfare and the minimization of the consequent environmental burden in allocation of land and water resources in irrigated agriculture. Weighted and Lexicographic GP technique were employed and implemented on a representative area. The results came as close as possible to the decision makers economic social and environmental goals. The information that was incorporated into the selected goals includes farmers' welfare, characterized by securing income and employment levels as well as environmental benefits, such as water resources protection from excessive application of fertilizers and from unsustainable use of irrigation water several weights or priority levels were assigned on the above goals. according to the intentions of the decision maker, that differentiated the final allocation of resources. Barnett et al. (2006) developed a methodology to estimate empirically the weights for a multiple goal objective function of Senegalese subsistence farmers. The methodology includes a farmer-oriented goal preference survey and an application of multidimensional scaling technique to the survey data. A comparison of model, performance under the multiple-goal objective function with a profit maximization objective function did not indicate there were distinctive advantages to using either function. Nhantumbo et al. (2006) presented a Weighted Goal Programming (WGP) approach for planning management and use of woodlands as well as a framework for policy analysis. The methodology was employed to reconcile demand of households, private sector and government of Miombo woodland of South Africa.

Moro and Ramos (1999) presented a goal programming methodology for solving maintenance scheduling of thermal generating units under economic and reliability criteria. Mathirajan and Ramanathan (2006) in their paper addressed a goal programming model for scheduling the tour of a marketing executive which is concerned with the determination of appropriate workforce requirements, workforce allocation and duty assignments in an organization in order to meet its internal and external commitments. Narayanan S. Partangel (1999) addressed a goal programming data envelopment analysis technique in manufacturing plant performance. In his research paper, serial-manufacturing goal programming model was discussed. Amiri et al. (2009) studied GP model for successful production and marketing. Hultz et al. (1981) studied on multi-activity, multi-facility problems and proposed an interactive solution method to compute non-dominated solutions to compare and choose each others. In the paper of Fortenberry and Mitry (1986), an application of integer goal programming for facility location with multiple competing objectives are addressed. Krukanont and S. Praertsan (2003) developed mathematical model for power plant where rubber woods were used as raw materials. Goal programming, a MOLP procedure, has been introduced as an alternative to linear programming for public forest management planning models incorporating multi-objective planning in the paper of Field et al. (1980).

Jsh Kornbluth (1973) applied goal programming model for industrial and economic planning. Samouilidis (1970) has employed the goal programming model for flows of funds in an economy. Charnes et al. (1969) used the GP framework for the solution of manpower planning problems. Jones and Salkin (1972) used the goal programming approach to formulate models of the acquisition problem. Ahmed K. Rifai and Joseph O. Pecenka (1986) has employed goal programming models for organizational sectors.

Shim and Siegel (1980) developed Goal Programming model with sensitivity analysis to determine the decision variables and goal deviations. Cobb and Warner (1973) and Trivedi (1981) used mixed integer GP model for resource allocation in order to solve management related problems for quality service. Thierauf et al. (1975) also employed mixed integer GP model for solution of problems associated with production planning.

The goal programming (GP) technique in solving agro-forestry management problems involving multiple objectives has become a widely used approach in Operation Research studies (Romero, 1986). The increasing popularity of GP and usefulness for decision-making policies has been aimed at optimizing agricultural land and other natural resources. GP technique can be used to address the problem of determining an optimum-cropping pattern by considering several goals in agricultural planning and management. Wheeler and Russell (1977) used a GP model to analyze the plantation of a farm in the United Kingdom. Ghosh (1993, 1995) presented a model for the allocation of land under cultivation for production of crops in different seasons in a year. Ghosh, Sharma and Mattison (2005) used a model for nutrient management for rice production. Also several studies have been used in natural resources planning (Romero, 1986), livestock ration formulation (Rehman and Romero, 1984, 1987), sugar beet fertilizer combination problems (Minguez, 1988).

Vivekandan et al. (2009) 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. Alade et al. (1998) developed a multi-objective model for the planning of developing countries. In their model, they examined industrial structure, labour force, vale added in export, capital efficiency, imported inputs for exports, investment planning etc. and it was applied for Indian economy. Jafari et al. (2008) formulated goal programming model for rice firm. In their study, the lexicographic goal programming model was considered to identify the optimal compound of agricultural product in the rice farm land.

The optimization model based on a single criterion does not often give acceptable solutions in practice especially in the case of natural resources. Romero and Rehman (1987) deemed that in management of natural resources, the social and environmental aspects of resource allocation cannot be ignored if the decisions taken are to be treated as realistic. Romero and Rehman review the applications of GP and MOP in fisheries, agricultural land

uses, forestry and water management. Hayashi (2000) reviews the applications of GP and MOP in agricultural resource management. Diaze-Balteiro and Romero (2003) developed a GP model that incorporates carbon sequestration, in terms of total carbon balance, as a complementary objective with other criteria including maximizing net present value, quality of harvest volume, area control in forest management. They also presented a state-of-the art analysis on multi criteria decision making including goal programming analytical hierarchy programming, and multi-attribute compromise programming, and discussed specific cases of multiple objectives including the volume of timber harvested, the economic return, and timber production and inventory policies. Wheeler and Russell (1977) considered a GP model for agricultural land management. In their paper planning of mixed farm was discussed. Field (1973) developed a GP model for forest planning management. In his paper many conflicting goals were addressed namely levels of profits, budget limits, timber harvesting targets. Krishna Rustagi (1973) considered a goal programming approach in forest management planning for timber production.

In the paper of Khwanchai and Pasti (2005), the advantage of a linear programming model in forestry is described and a forest plantation of the forest industry organization, a teak plantation, is taken as an example. Suresh Chand Sharma et al. (2010) proposed a goal programming model for tracking and tackling environmental risk production planning problem that includes minimization of damages and wastes in the milk production system. T. Gomez et al. (2006) presented a linear fractional goal programming model to a timber harvest scheduling problem in order to obtain a balanced age class distribution of a forest plantation in Cuba. Andres Weintraub et al. (2001) studied the role of operational research discipline in the understanding and management of renewable resources in the areas of agricultural, fisheries and forestry. Alireza Karbasi et al. (2012) discussed the goal programming for the optimal combinations of different kinds of fertilizers for rice cultivation. In the paper of Shaik Md. et al. (2010), a multi-objective forest management process employing mathematical programming and the analytical hierarchy process had been developed for systematically incorporating public input.

V. CONCLUSION

The Goal Programming appears to be an appropriate, powerful and flexible technique for decision analysis of the troubled modern decision maker who is burdened with achieving multiple conflicting objectives under complex environmental constraints. The modelling approach does not attempt to maximize or minimize the objective function directly as in the case of conventional Linear Programming. Goal Programming model seeks to minimize the deviations between the desired goals and the actual results to be obtained according to the assigned priorities.

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