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An Application of Integer Linear Programming Problem in Tea Industry of Barak Valley of Assam, India under Crisp and Fuzzy Environments

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Abstract. The current paper is concerned with a decision making problem of a tea industry of Barak Valley of Assam, India. The goal of this problem is to maximize the overall profit of the industry subject to the given resource constraints. Firstly, the problem has been formulated as an integer linear programming problem in crisp as well as in fuzzy environment. For fuzzification of the problem, some of the parameters are assumed to be different types of fuzzy numbers viz., triangular fuzzy number, parabolic fuzzy number and trapezoidal fuzzy number. Thereafter, the problem has been defuzzified by graded mean integration method to convert the crisp problem. The converted problem has been solved by the software LINGO13.0. Finally, to illustrate the problem and its results, a numerical example has been solved.

Keywords: Linear programming, Fuzzy Set, Industrial problem

1. Introduction

Due to competitive market situation as well as global economy of the market, the manager of an industry is always searching for the global solution for their problems to take appropriate (optimum) decision. Also due to uncertain situation, some of the parameters of the industry problem are not precise. These parameters may be imprecise. To tackle the problem with such imprecise numbers, generally stochastic, fuzzy and fuzzy stochastic approaches are applied and the corresponding problems are converted to crisp problems for solving those. In solving the converted problem, mathematical programming plays an important role.

In tea industry, there arise different types of decision making problems. To the best of our knowledge, no much work has been done on the applications of mathematical programming in tea industry. Deb (1999) first studied the transportation problem of tea industries of Barak Valley of Assam. Motivating from this work, Sinha and Sen (2011) developed a goal programming model for same industries. Recently, Sen (2012) extended the work of Sinha and Sen (2011) by considering several goals based on profit, production, demand, use of processing machines. In all these studies, the values of the system parameters were precise i.e. the values of the parameters were considered in crisp environment. However, in reality, these parameters may not be precise due to uncertainty (more precisely due to human error, improper storage facilities and other unexpected factors relating to environment).Therefore, in modeling of the problems, these parameters are considered as imprecise. To tackle the problem with such imprecise numbers, generally stochastic, fuzzy and fuzzy stochastic approaches are applied and the corresponding problems are converted to deterministic problems for solving those.

2. Representation of Fuzzy Number

The concept of 'fuzzy' was first introduced by Zadeh (1965) in his famous research paper "Fuzzy Sets" to represent the impreciseness/fuzziness or vagueness of a parameter mathematically. The approach of fuzzy set is an extension of classical set theory. In classical set theory, the membership of each element in relation to a set is assessed according to a crisp condition; an element either belongs to or does not belong to the set.

In contrast, a fuzzy set theory permits the gradual assessment of the membership of each element in relation to a set; this can be shown with the help of a membership function. In classical set theory, a membership function may act as an indicator function, mapping all elements to either 1 or 0. In a fuzzy set, a membership function is defined for each element of the referential set. After Zadeh (1965), the subject was enriched by Zimmermann (1976) and Bellman and Zadeh (1970).To tackle the problem with fuzzy parameters, first of all the problem is to be defuzzified. For this defuzzification, there are several techniques available in literature. In this connection, one may refer to the works of Ming et al. (2000), Yager et al. (1993) and Chen and Hsieh (1999). Among them, Chen and Hsieh (1999) proposed graded mean integration representation method on integral value of graded mean α-level of generalized fuzzy number for defuzzification of generalized fuzzy number.

2.1. Fuzzy Set

A fuzzy set $\tilde{A}$ in a universe of discourse X is defined as the set of pairs $\tilde{A} = \{(x, \mu_{\tilde{A}}(x)) : x \in X\}$, where $\mu_{\tilde{A}} : X \to [0,1]$ is a mapping and $\mu_{\tilde{A}}(x)$ is called the membership function of $\tilde{A}$ or grade of membership of x in $\tilde{A}$.

2.1.1. Convex Fuzzy Set

A fuzzy set $\tilde{A}$ is called convex if and only if for all $x_1, x_2 \in X$, $\mu_{\tilde{A}}(\lambda x_1 + (1-\lambda)x_2) \ge \min\{\mu_{\tilde{A}}(x_1), \mu_{\tilde{A}}(x_2)\}$, where $\lambda \in [0,1]$.

2.2.2. Support of a fuzzy set

The support of a fuzzy set $\tilde{A}$ denoted by $S(\tilde{A})$ is the crisp set of all $x \in X$ such that $\mu_{\tilde{A}}(x) > 0$.

2.2.3. α -level Set

The set of elements that belong to the fuzzy set $\tilde{A}$ at least to the degree α is called the α -level set or α -cut and is given by $\tilde{A}_\alpha = \{x \in X : \mu_{\tilde{A}}(x) \ge \alpha\}$. If $\tilde{A}_\alpha = \{x \in X : \mu_{\tilde{A}}(x) > \alpha\}$, it is called strong α -level set or strong α -cut.

2.2.4. Normal Fuzzy Set

A fuzzy set $\tilde{A}$ is called a normal fuzzy set if there exists at least one $x \in X$ such that $\mu_{\tilde{A}}(x) = 1$.

2.3. Fuzzy Number

A fuzzy number is a special case of a fuzzy set. In this connection, different definitions and properties of fuzzy numbers are encountered in the literature. However, in all these definitions, the main theme is that a fuzzy number represents the notion of a set of real numbers 'closer to a' where 'a' is the number being fuzzified. A fuzzy number is a fuzzy set which is both convex and normal.

Here we shall discuss three different types of fuzzy numbers, viz. Triangular, and Parabolic and Trapezoidal fuzzy numbers.

2.3.1. Triangular Fuzzy Number (TFN)

A triangular fuzzy number $\tilde{A}$ is represented by the triplet (a_1, a_2, a_3) and is defined by its continuous membership function $\mu_{\tilde{A}}(x) : X \to [0,1]$ given by