CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

The basic transportation problem was originally developed by Hitchcock (1941). Efficient methods of solution are derived from the simplex algorithm and were developed in 1947. The transportation problem can be converted as a standard linear programming problem, which can be solved by the simplex method. However, because of its very special mathematical structure, it was recognized early that the simplex method applied to the transportation problem can be made quite efficient in terms of how to evaluate the necessary simplex-method information (variable to enter the basis, variable to leave the basis and optimality conditions).

Charnes et al (1954) developed the Stepping Stone Method which provides an alternative way of determining the simplex-method information. Dantzig (1963) used the simplex method in the transportation problem as the Primal simplex transportation method. An initial basic feasible solution for the transportation problem can be obtained by using the North West corner rule, Row minima, Column minima, Matrix minima, or the Vogel’s approximation method. The Modified Distribution method is useful for finding the optimal solution for the transportation problem.

The Linear Interactive and Discrete Optimization (LINDO), General Interactive Optimizer (GINO) and TORA packages as well as many
other commercial and academic packages are useful to find the solution of the transportation problem.

Arsham et al (1989) introduced a new algorithm for solving the transportation problem. The proposed method used only one operation, the Gauss Jordan pivoting method, which was used in simplex method. The final table can be used for the post optimality analysis of transportation problem. This algorithm is faster than simplex, more general than stepping stone and simpler than both in solving general transportation problem.

Kikuchi (2000) suggested that, in many problems of transportation engineering and planning, the observed or derived values of the variables are approximate. Yet, the variables themselves must satisfy a set of rigid relationships dictated by physical principle. They proposed a simple adjustment method that finds the most appropriate set of crisp numbers. The method assumes that each observed value is an approximate number (or a fuzzy number) and the true value was found in the support of the membership function. For each of many possible set of values that satisfy the relationships, the lowest membership grade is checked and the set, whose lowest membership grade is the highest, is chosen as the best set of values for the problem. This process is performed using the fuzzy linear programming method.

The multi-objective transportation problem refers to a special class of linear programming problem in which the constraints are of equality type and all objectives are conflicting with each other. All the proposed methods to solve multi-objective linear programming problem generate a set of non-dominated or compromise solution. A variety of approaches, such as lexicographic goal programming approach, interval goal programming approach, interactive algorithms, fuzzy programming approach, the step
method, the utility function method have been developed by many researchers for the multi-objective linear programming problem.

Lee et al(1973) applied goal programming to find a solution is multi- objective transportation problem. Goal programming has been widely applied to solve different problems which involves multiple objectives. Virtually, all models developed to solve transportation problems ignored the multiple conflicting objectives involved in the problem. The priority structures of these objectives are various environmental constraints, unique organizational values of the firm, and bureaucratic decision structures. However, in reality these are important factors which greatly influence the decision process of transportation problems. They studied the goal programming approach which is utilized in order to allow for the optimization of multiple conflicting goals while permitting an explicit consideration of the existing decision environment.

Zimmermann (1978) applied the fuzzy set theory concept with some suitable membership function to solve multi-objective transportation problems. He presented the application of fuzzy linear programming to approach linear vector maximum problem. It has been found that solutions obtained by fuzzy linear programming are always efficient. Isermann (1979) developed an algorithm for identifying all the non-dominated solutions for a linear multi-objective transportation problem.

Leberling (1981) used hyperbolic membership function for multi-objective linear programming problem. He found that using the fuzzy min-operator together with linear as well as special nonlinear membership functions (hyperbolic) the obtained solutions are always compromise solutions of the original multi-criteria problem.
Slowinski (1986) presented a method for solving a multi-criteria linear program where the coefficients of the objective functions and the constraints are fuzzy numbers of the L-R type. He transformed the original problem into a multi-criteria linear fractional problem by assuming the aspiration levels for particular criteria to be fuzzy and based on comparison of fuzzy numbers, and then solving the obtained problem by using an interactive technique involving a linear programming procedure in the calculation phase.

Ringuest et al (1987) proposed interactive algorithms to find $k$ non-dominated and dominated solutions, if there are $k$ objectives. Thus the decision maker has to determine a compromise solution from the set of non-dominated solutions. For the larger problem, it is not easy to find the compromise solution by using the algorithm developed by Ringuest and Rinks (1987) but, using the fuzzy programming method, one can easily find a compromise solution.

Sakawa et al (1987) proposed an interactive fuzzy decision making model using linear and non-linear membership functions to solve the multi-objective linear programming problem. Dhingra et al (1991) defined some non-linear membership functions like exponential, quadratic and logarithmic, and applied them to an optimal design problem. This procedure is useful in engineering and management design situations where uncertainty or ambiguity arises about the preciseness of permissible parameters, degree of credibility, and correctness of statements and judgements.

Bit et al (1992) considered a $k$-objective transportation problem fuzzified by fuzzy numbers and used $\alpha$-cut to obtain a transportation problem in the fuzzy sense expressed in linear programming form. Bit et al (1993) introduced an additive fuzzy programming model for the multi-objective transportation problem. The method aggregates the membership functions of the objectives to construct the relevant decision function.
Weights and priorities for non-equivalent objectives are also incorporated in the method. This model gives a non-dominated solution which is nearer to the best compromise solution.

Verma et al (1997) proposed a special type of non-linear (hyperbolic and exponential) membership functions to solve the multi-objective transportation problem and compared the obtained result with the solution obtained by using a linear membership function and has shown that the results were found to be nearly same. Hussien (1998) studied the complete set of $\alpha$ - possibly efficient solutions of multi-objective transportation problem with possibility coefficients of the objective functions.

Das et al (1999) focused on the solution procedure of the multi-objective transportation problem where the cost coefficients of the objective functions, and the source and destination parameters are expressed as interval values by the decision maker. They transformed the problem into a classical multi-objective transportation problem so as to minimize as the interval objective function. They defined the order relations that represent the decision maker’s preference between interval profits. They converted the constraints with interval source and destination parameters into deterministic one. Finally, they solved equivalent transformed problem by fuzzy programming technique.

Li et al (2000) presented a fuzzy compromise programming approach to multi-objective transportation problem. A characteristic feature of the approach proposed is that various objectives are synthetically considered with the marginal evaluation for individual objectives and the global evaluation for all objectives. The decision-makers preference is taken into account by assigning the weights of objectives. With the global evaluation for all objectives, a compromise programming model is formulated. Using ordinary optimization technique, fuzzy compromise programming model is
solved to obtain a non-dominated compromise solution at which the synthetic membership degrees of the global evaluation for all objectives are maximum.

Wahed et al (2001) presented a fuzzy programming approach to determine the optimal compromise solution of a multi-objective transportation problem and tested the approach performance by measuring the degree of closeness of the compromise solution to the ideal solution using a family of distance functions.

Sakawa et al (2001) dealt with actual problems on production and work force assignment in a housing material manufacturer and a subcontract firm. He formulated two kinds of two-level programming problems: one is a profit maximization problem of both the housing material manufacturer and the subcontract firm, and the other is a profitability maximization problem of them. Applying the interactive fuzzy programming for two-level linear and linear fractional programming problems, he obtained the satisfactory solution to the problems.

Ammar et al (2005) investigated the efficient solution and stability of multi-objective transportation problem with fuzzy coefficient and/or fuzzy supply quantities and/or fuzzy demand quantities. Wahed et al (2006) proposed an interactive fuzzy goal programming approach to determine the preferred compromise solution for the multi-objective transportation problem. The proposed approach considers the imprecise nature of the input data by implementing the minimum operator and also assumes that each objective function has a fuzzy goal. The approach focuses on minimizing the worst upper bound to obtain an efficient solution which is close to the best lower bound of each objective function. The solution procedure controls the search direction via updating both the membership values and the aspiration levels.
Zangiabadi et al (2007) presented a fuzzy goal programming approach to determine an optimal compromise solution for the multi-objective transportation problem by assuming that each objective function has a fuzzy goal. A special type of non-linear (hyperbolic) membership function is assigned to each objective function to describe each fuzzy goal. The approach focuses on minimizing the negative deviation variables from one to obtain a compromise solution of the multi-objective transportation problem.

Surapati et al (2008) presented a priority based fuzzy goal programming approach for solving a multi-objective transportation problem with fuzzy coefficients. Initially, they defined the membership functions for the fuzzy goals. Subsequently, they transformed the membership functions into membership goals, by assigning the highest degree (unity) of a membership function as the aspiration level and introducing deviational variables to each of them. In the solution process, negative deviational variables are minimized to obtain the most satisfying solution.

Lau et al (2009) presented an algorithm called the fuzzy logic guided no dominated sorting genetic algorithm to solve the multi-objective transportation problem that deals with the optimization of the vehicle routing in which multiple depots, multiple customers, and multiple products are considered. Since the total travelling time is not always restrictive as a time constraint, the objective considered comprises not only the total travelling distance, but also the total travelling time.

Lohgaonkar et al (2010) used fuzzy programming technique with linear and non-linear membership function (hyperbolic, exponential) to find the optimal compromise solution of a multi-objective capacitated transportation problem.
Motivated and prompted by the works of Chanas et al (1996) and Abd El-wahed et al (2006), this thesis presents a significant departure from the traditional way of dealing with fuzzy transportation problems. In general it is believed that the membership functions are best represented by non-linear functions. In the more general case of non-linear membership functions the transportation process becomes considerably complex, and in the past, typically led to less desirable formulations. Hence, in this thesis triangular fuzzy numbers and trapezoidal fuzzy numbers are used to serve as a parameter for fuzzy transportation problems, while a linear membership function in the case of fuzzy transportation permits an easy conversion into an ordinary transportation problem. In this thesis, an effort has been made to prove that the algorithm for transportation problems and fuzzy transportation problems could be verified by C#Net program.