Preface

This thesis has been prepared to present some methodological aspects of multiobjective programming and their potential uses to real-life problems with data uncertainty in decision environment. Multiobjective programming is actually an extension of conventional single-objective programming in the area of mathematical programming and is concerned with problems of making decisions with multiplicity of objectives in real-world decision situations.

In actual practice, today human is facing the problem of modeling multidimensional characteristics of most of the real-world problems, such as, social, economic, environmental and technological and other ones. Here, it is worth mentioning that the main difficulty of solving problems with plurality of objective functions over the traditional single-objective optimization problems is that the multiple objectives normally incommensurable in nature and often conflict each other regarding individual optimization of them in a practical decision situation. To cope with the situation, multiobjective programming approaches to multiobjective decision problems have been introduced in the area of mathematical programming. It may be noted here that from mid-1960s to 1970s of the last century several multiobjective decision making approaches have been introduced by the pioneer researchers in the field and applied to several real-world decision problems.

However, in a multiobjective programming environment, various factors which are inherent to representing objective functions and system constraints of a problem are critically involved in a real decision situation. Actually, the main difficulty with that of describing different types of parameters associated with modeling the objectives and constraints of a multiobjective problem. In the traditional approaches, the values of such parameters are often defined precisely through decision makers’ understanding of the nature of decision problems.

In context to the above, it is to realized to the fact that values of model parameters are often ambiguously known to the decision makers (experts) owing to imprecision or inexactness of human judgments as well as uncertain in nature of the parameters themselves.

To cope with the above situation, the three prominent approaches developed in the programming environment are “fuzzy programming”, “interval programming”, [xxi]
and "stochastic programming". As an essence, the two types of inexactness would have to be incorporated in modeling multiobjective decision problems. The first one is decision maker’s ambiguous understanding of the nature of parameters (fuzzy or interval or random) in the problem formulation process, and the other one is inexactness of setting the aspiration levels of achieving objectives in an uncertain environment.

In the above context, considering the imprecise or fuzzy nature of human judgments, fuzzy set-theoretic approaches have appeared as one the most promising tools for dealing with real-world decision problems. The theory of fuzzy sets, initially introduced by Lofti A. Zadeh in 1965, is basically a theory of graded concepts — a theory in which everything is a matter of degree. Since its inception, the notion of fuzzy sets for decision analysis has advanced in a variety of ways and in many disciplines. One of the most important areas of applications of this theory is the mathematical programming.

Fuzzy programming approaches to solving single-objective as well as multiobjective optimization problems have been studied deeply in the past by pioneer researchers in the field. During the last thirty years, methodological developments for multiobjective decision making in fuzzy environment have drawn enormous attentions of researchers in the field. In particular, special emphasize has been given to fuzzy programming formulation of conventional goal programming based on the satisficing philosophy, expounded by the Noble Laureate H. A. Simon in 1945 from the view point of accommodating imprecisely described real-life decision problems. Actually, the theory of fuzzy sets has been recognized as a promising tool for human-centered decision making in the current complex multiobjective decision-making arena.

Although, fuzzy goal programming as an extension of conventional goal programming as well as other fuzzy programming methodologies have been investigated a lot in the past for multiobjective decision analysis, the extensive study in the field and their uses to real-world decision problems are still at an early stage.

Now, in some of the practical decision situations, it has been realized that fuzziness cannot always cope with real systems. It has been recognized that the better is to describe interval data sets for model parameters rather than defining them imprecisely. Here, interval programming approach has appeared as another efficient
approach to solving problems in the area of inexact programming. From a historical perspective, the seeds of interval programming can be traced in the third century BC, when Archimedes (the father of mathematics) calculated the value of \( \pi \) (pi) with certain lower and upper bounds \( (223/71 < \pi < 22/7) \) on it. The study on interval programming and the modeling aspects of decision problems within the framework of goal programming has been investigated in the past.

In case of solving several real-life problems, like water resource planning problems, mobile path planning problems, portfolio selection problems, and agricultural planning, it is found that decision makers often feel are comfortable to solve problems with intervals data rather than crisp / fuzzy aspect of setting parameter values. During the last twenty years, although different methodological aspects of interval programming have been studied by the researchers in the field, exploration of them is still at an early stage.

In some practical decision situations, decision makers are still facing the problem with inherent random in nature of some of the parameters, where probabilistically defined objectives/ constraints need be accommodated along with consideration of fuzzy/ interval data sets associated with a decision problem in uncertain environment. Consequently, the stochastic programming approach, initially introduced by Dantzig in 1955, is to be taken into account in various decision making situations. Actually, consideration of above mentioned three types data uncertainty is now a great challenge to decision makers in the current complex uncertain decision making environment.

In this study, the consideration of three types data are considered for modeling and solving multiobjective decision problems in different situations of programming and planning environment. For systematic and thorough presentation of the study materials, the thesis is divided into 13 Chapters.

Chapter 1 discusses the literature on single-objective as well as multiobjective decision making methods and applications in crisp and inexact environments. Actually, the survey provides a history of the methodological developments of single-objective programming and multiobjective programming approaches. As a special case, mathematical frameworks of goal programming and fuzzy programming are discussed in greater details as prominent tools for multiobjective decision analysis in real decision situations. A new look into the way of formulating fuzzy goal
programming model is also provided as one of the prominent and growing tool for multiobjective decision making in fuzzy environment.

Then, brief literatures on interval programming and stochastic programming are introduced. The basic concepts of some interval arithmetic rules which are useful to decision problems are discussed in brief. The different methodological aspects of conventional stochastic programming are also presented in brief to highlight their usefulness to current decision making problems.

The background materials presented in the first Chapter actually provide an added insight into presentation of the later chapters.

Chapter 2 – 13 are concerned with the contributory venture of the present work.

Chapter 2 presents an iterative parametric approach, based on Dinkelbach’s method of solving single-objective fractional programming problems, for solving multiobjective decision problems with fractional criteria and interval parameter sets. The interval goal programming method is introduced for modelling and solving a problem without using linearization technique in the solution search process.

In Chapter 3, the modeling aspects of a bilevel programming problem with fractional in form of both the objectives in a hierarchical decision system in fuzzy environment is considered. In the solution process, linear transformation technique is used to solve the problem by employing linear FGP methodology and thereby arriving at an appropriate decision for balancing the decision powers of the decision makers for overall benefit of the organization.

Chapter 4 and Chapter 5 are devoted to fuzzy goal programming formulations of general multiobjective decision problems and multilevel programming problems within hierarchical decision structure, respectively, under stochastically defined system constraints sets in the decision environment.

Chapter 6 describes the concept of grafting penalty functions within the framework of fuzzy goal programming for multiobjective decision making in uncertain environment.

Chapter 7 demonstrates the use of mixed 0-1 programming method within the framework of goal programming to solve chance constrained multiobjective decision problems in the uncertain decision environment.

Chapters 8-12 deal with potential uses of multiobjective decision making methods for solving real-world multiobjective problems in inexact environment.
In Chapter 8, effective use of interval goal programming method for solving academic personnel planning problems in university management system is investigated.

Chapter 9 demonstrates a priority based goal programming method for modeling and solving agricultural problems with interval parameter sets under a chance constrained set for crop production planning in a farm management system.

Chapter 10 presents how both fuzzy and interval data sets can be effectively used for modeling and solving patrol manpower deployment problems in a traffic management system.

In Chapter 11, a priority based fuzzy goal programming formulation of economic power generation and dispatch as well as controlling environmental-emission problem in a thermal power plant operation and planning situation is considered.

Chapter 12 deals with the use of interval goal programming approach for optimal power generation and dispatch problems under different loading conditions and following 1990’s ‘Environmental Pollution Act’ in the decision situation.

Finally, Chapter 13 provides general conclusions and future research directions in the area of study.

An updated bibliographical listing of 144 books, monographs or Conference Proceedings, and 344 selected papers and reports of theses are presented at the end of the study.

A set of photocopies of 8 selective published papers are also attached with the thesis.