Chapter 12

Conclusion and Scope for Future Research
12.1 Conclusions

Optimization is a common need in every sphere of life ranging from manual to automated one. Decision making with imprecise data in inexact environment is an emerging need of the world. Uncertainty and randomness is an integral part of most of the events in real world in which it has been observed that more than one type of inexactness among three most significant type (namely stochastic, fuzzy and interval-valued ness) are inherently associated with the parameters of real-world problems. From the second-half of the previous century, inexact programming (fuzzy programming, stochastic programming and interval programming) has been investigated for decision making in inexact environment. Its scope of use covers a huge spectrum of domains across various disciplines viz. water resource planning, road safety and accident reduction, academic resource utilization in university management systems, land utilization and agricultural planning, inventory control systems, ant-colony optimization, mobile robot path planning, portfolio selection, share and financial management, hierarchical decision making in large scale organization, weather forecasting, surface and air transport, pattern recognition, soft computing and many more areas.

In this thesis, different aspects of decision making problems with single as well as multiple criteria have been investigated in inexact environment. Methodological developments and computational aspects of stochastic programming, fuzzy programming and interval programming have been discussed in detail in the preceding chapters of this thesis.

Moreover, the use of GA inspired by principles of natural selection and population genetics has been taken into consideration in the solution search process of all the problems. The methodological aspects of genetic algorithm have been discussed and how it has been employed in the decision process under the framework of FGP, with stochastic simulation and with interval objectives has been investigated.

In the present work, use of GA with one or more type of imprecision (stochastic, fuzzy or interval) has also been investigated in different area of MP including hierarchical decision making problems.

MODM with fractional objectives have been extensively discussed in Chapter 2 to Chapter 4 under the framework of FGP. Fractional objectives with the use of IvP
have been discussed in Chapter 5. In minimizing the associated deviational variables under the framework of FGP, both the aspects of weights of importance as well as priority structure are taken into consideration in the model formulation of those problems.

Bilevel programming problems with fractional objectives that represent the conflict of interest between two decision makers placed at two different levels in large hierarchical decision making organization has also been investigated.

The aspects of involving randomness in parameters under the area of study of stochastic programming and chance constrained programming as a special field of study of SP have been investigated extensively in the next three chapters (Chapter 6 to Chapter 8).

The chance constrained fuzzy goal programming problems have also been investigated in the present work. The successful use of stochastic simulation and deterministic conversion of probabilistic constraints for different distributions of the model parameters have also been considered in the decision making situations.

The application potential of GA in inexact environment with the use of FGP has been studied to the possible extent in Chapter 9 to Chapter 11 of this thesis. The collection of real-world sample data in three different areas of study: academic personnel planning problem in University management systems, land utilization for optimal cropping in Agricultural systems, and patrolman allocation problem in Traffic management systems and the potential application of GA approaches to the selected problems are exposed extensively in the decision making situations.

12.1 Future Scope of Research

MODM in Inexact decision environment is an emerging field of study from the point of view of implementation to various branches of real-world problems. Here, Fuzzy Programming is relatively new field of study in comparison to stochastic programming and interval programming.

The implementation of GA methods to various MODM problems is still at an initial stage, and future scope of study is inevitable here in contrast to contribution to the existing methodological aspects for solving a variety of problems.
As an extension of the previous studies, certain areas of study have been discussed in the preceding chapters.

However, some of the areas in which deep study in future are essentially needed may be summarized as follows:

- Soft Computing for MODM is an emerging area of study for exploration of different practical problems and making proper decisions in different inexact decision making environments. Although, independent methodological growth of FP, IvP, and stochastic-fuzzy programming as well as combination of few of them in the area of soft computing have been made in the past few years, and a few of them has been extended and discussed to the extent possible in the present thesis from the point of view of their implementations, an extensive study is urgently needed there to solve several practical decision problems.

- The incorporation of neural network [232] approaches in the frameworks of the approaches studied in the present thesis may be considered as one of the important research area in the current complex inexact decision making arena.

- Scope remains for future research in the area of hierarchical decision making problems in the decentralized programming and planning horizon.

- The implementation of GA methods to the classical transportation problems with random and fuzzy parameters is yet to be circulated widely in the literature. It may be considered as one of the emerging research area.

- The Fuzzy stochastic programming with the use of fuzzy random variables is relatively new area of research, and use of GA there is an open problem for substantial growth of the area of the study.

- Scope of research remains in developing the methodological aspects of Interval programming and Interval Goal programming. The incorporation of randomness of the parameter values to the problems [381] is still at an early stage. The use of interval-valued parameters in uncertain decision environment is yet to be explored extensively in contrast to the use of randomness and fuzziness [303] in other MODM areas.

- The use of hybrid GA [288, 512] to different real-world problems is a growing area of research, and further extension of the study area along with
implementation to the problems studied in the thesis are highly desired for searching better decisions there, if any, in the decision making situations.

- The extensive investigations on Genetic programming [265, 266] and generic optimization [205] may also be considered in future research for efficient implementation of them to MODM problems.

Finally, it is hoped that the methodological development of Multiobjective Decision Making in inexact environment and use of GA here will propel wide applications to real-world decision problems and would drive it to a "Workhorse" for multiobjective optimization in near future in the current complex decision making horizon.