Chapter 33
A Genetic Algorithm to Goal Programming Model for Crop Production With Interval Data Uncertainty

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ABSTRACT

This chapter presents how Genetic Algorithm (GA) is effectively employed to Goal Programming (GP) formulation of an agricultural planning problem having interval model parameters and a set of chance constraints for optimal production of seasonal crops in uncertain environment. In model formulation, the planned-interval goals associated with objectives of the problem are converted into their equivalent two-objective deterministic goals. The chance constraints are also converted into their deterministic equivalents to solve the problem by using GP methodology. In goal achievement function, minimization of deviational variables associated with model goals is evaluated on the basis of priorities by employing a GA scheme to reach optimal decision. In the decision process, sensitivity analysis with variations of priority structure of goals is performed, and then the notion of Euclidean distance function is used to identify the priority structure under which optimal production of crops can be obtained in the decision environment. A case example is considered to demonstrate the approach.

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INTRODUCTION

The history of human civilization shows that domestication of plants went on as far as 7800 B.C. and forest gardening for plant-based food production, world's oldest form of agriculture, was started as far back as 5200 B.C. Actually, development of agricultural production system is the root of starting human civilization. The rapid rise in human civilization due to technological innovations, significant improvements in agricultural techniques were taken place from the mid-12th century to 13th century and stayed steady until 18th century (Campbell, & Overton, 1993). However, owing to rapid rise of mechanization in the late 19th century and 20th century, farming tasks could be done with a tremendous speed and became more sustainable due to innovation of tillage tools. In reality, advancement of technology has led to enable to start the modern farming system on earth (Mazoyer, & Roudart, 2006). It is worthy to mention that crop production problem is actually a management science problem with multiplicity of objectives, where the objectives are to optimize production of crops and thereby to meet the need of agricultural products in society. The general mathematical programming (MP) model for allocation of cultivable land with regard to yielding of crops to optimal levels was first presented by Heady (1954). It may be mentioned that, although land utilization system for cultivation as well as water supply system for irrigation were improved a lot prior to middle of the last century, Green Revolution was actually taken place during 1960s due to the pioneer contributions of Nobel Laureate Norman Ernest Borlaug. The effective mathematical models were then developed to take measure for better water supply and land allocation decisions for crop production. A bibliography on the modeling of agriculture planning problems was first presented by Nix (1979). Then, study on implementation of management science models to farm planning problems were made deeply towards growth of agro-economic scenarios in the modern world.

Now, since agricultural planning problems are typically multiobjective problems in the premises of limited supply of farming resources and optimal of production of several crops to meet food products in society, goal programming (GP) method (Ignizio, 1976), that is based on satisficing philosophy (Simon, 1945), was introduced to a crop production planning problem by Wheeler, and Russell (1977). The survey on the study of agricultural planning models was further conducted by Norton, and Schiefer (1980), Glen (1987) among others.

However, in most of the cases of modeling the real-world multiobjective decision making (MODM) problems, it may be noted that decision makers (DMs) are faced with the problem of setting precise model parameters to the problems owing to inherent imprecise nature of parameters and ambiguity in human judgments. To cope with the situation, fuzzy programming (FP) (Zimmermann, 1987) approach based on the theory of fuzzy sets, initially proposed by Zadeh (1965), has been employed to farm planning problems with imprecisely defined model data by Slowinski (1986). Again, Fuzzy goal programming (FGP) (Pal, & Moitra, 2003) as an extension of FP within the framework of GP has been used to agricultural land allocation problem by Biswas and Pal (2005).

Further, in a farm planning environment, it is to be observed that some of model data, which are inherently associated with resource utilization constraints, are probabilistically uncertain (Liu, 2003) in nature. The stochastic programming (SP) (Charnes, & Cooper, 1959) method was studied (Kall, & Wallace, 1994; Sahinidis, 2004) extensively and implemented to practical problems (Bravo, & Ganzalez, 2009; Pal, Chakraborti, & Biswas, 2009). However, the use of such an approach to agricultural system is yet to be studied deeply in literature.

Again, in an uncertain environment, it may become difficulty to DMs to specifying fuzziness of model parameters as well as defining of probability distributions of them (Jiang, Han, Liu, & Liu,