Chapter 16
A Model for Planning the Sowing of Agricultural Crops and Raising Animals Through Two-Stage Mathematical Programming

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ABSTRACT

In this chapter, the authors present a mathematical model to calculate the exact quantities of animals that must compose a herd given the water, food, and land conditions available for their breeding. In the same model, the optimal calculation of vegetables that can be cultivated in the available land spaces is incorporated considering the same restrictions of water, nutrients, and area available for planting. Both models focus primarily from a deterministic perspective. Subsequently, the randomness of the same is uncovered through the uncertainty in the availability of water. Therefore, the first part of the proposal is made through a simple model of linear mathematical programming. The stochastic model is constructed from a two-phase mathematical programming model. The novelty of the proposal and its contribution consists of illustrating, step by step, the construction and solution of the scenarios of the stochastic model for a problem related to agriculture and animal husbandry.

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INTRODUCTION

Stochastic integer programming problems combine the difficulty of stochastic programming with integer programming. These problems involve the uncertainty that usually accompanies real problems. Sometimes, the parameters are known only within certain bounds, and an approach to tackling such problems is called robust optimization. On the other hand, in stochastic optimization one finds that there is not sufficient information about one or several parameters of the problem or that the information is scattered, diffuse or in the form of sample statistics. Under this scheme, the mathematical model is usually constructed using probability distributions to represent the uncertainty inherent in it. If this is the situation, the model is somewhat more accessible to solve using closed mathematical programming techniques or using metaheuristics based on simple rules that provide acceptable solutions in short times.

Mathematical modeling and the corresponding optimization of instances using models of two or more stages is one of the most challenging problems due to the discrete nature of the model and the non-convexity of the model. However, the richness of its applications makes it a necessity today where it is used in a wide number of fields. Traditionally, two totally different approaches are found for the process of decision making under the uncertainty environment. The first is called "Here and now" and consists of making a decision, waiting to see what nature offers and making the corresponding adjustments to the mistakes made. The second is called "Wait and observe," and as its name implies, the decision is made once the results that nature provides for the analyzed situation are presented.

In this document a proposal is developed which finds the optimal scenarios associated with a problem of planting vegetables and raising animals under an environment of uncertainty. The model is developed under different contexts explaining the models derived from each decision under the "Here and now" scheme. The results of the model are reported and the models illustrate the way they are obtained. The uncertain parameters of yield amount and price level are calculated using real data.

Usually a decomposition algorithm, which is enhanced with specialized Benders cuts for solving the stochastic problem must be used. However, we present a simple solution for the size of the instance managed through the different scenarios via mixed integer linear programming. The proposal begins with a deterministic model that seeks to maximize the utility of the investment measured as the difference between the expenses of the project and its income in a limited land area. Subsequently, the uncertainty is introduced through a simple probability distribution to illustrate the rain probabilities of the model. Variants of it is shown to illustrate the possibilities of the case. Following is our proposal. Our proposal is applicable in any known area of land or with any type of animal and/or vegetable. The model developed here is universal. The instance proposed here has already been tested in Mexican lands where the water conditions described in the model are presented71

Like any mathematical model, this proposal is based on a set of assumptions, for example proportionality in linear programming models, and the ease of constructing a probability distribution from sample data for the two-stage programming model. Naturally, any failure to comply with these assumptions leaves out the theory developed in this regard. This proposal is a mathematical model built to help in making decisions regarding the availability of inputs. It is not a proposal to build any engineering contraption to carry out the planting of vegetables or the raising of animals. These tools are applied posteriori, once the optimal decisions to make and the alternatives offered by the mathematical model are known.

The proposed instance and models with these characteristics can be in any of the following situations: a) There is a solution and it is unique, b) there is no solution, c) There are several solutions.