Handbook of Operations Research in Agriculture and the Agri-Food Industry
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Lluis M. Plà-Aragonés
Editor

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The use of OR in Natural Resources has been with us for several decades now. It has been developed importantly in the areas of forestry, agriculture, and mining. The papers published in the literature show results that go from methodological developments to case studies to actual applications used in industry or government. One area where OR has shown particular success has been in forestry. This has been driven in large part by the fact that forest lands and firms are quite large in both area and financial resources. Thus, there is the possibility and incentive to invest in using sophisticated tools for management. We see in this special issue the fruits of similar developments mainly in the area of agriculture. This is so because Agriculture and the Agri-Food Industry are becoming capital intensive and a more complex business than traditionally was. The academic and practical use of quantitative tools to support decision making in agriculture is shown in its many facets. The papers and the problems in them represent the typical challenges managers face:

- Planning of planting and harvesting.
- Production and logistics.
- Optimizing the supply chain.
- Risks of catastrophic events.
- Hierarchical planning.
- Multiobjective decision making.

These are areas where it is well known that Operations Research has proven its high value, with its tools to solve problems, and perhaps more importantly, in the way it helps, defines the issues, and characterizes the problems to be solved. The use of OR tools has become more important given the increased specialization of the sector, higher competition in a globalized world, need to produce and distribute in an efficient way, and the huge improvement in software and hardware possibilities. Additional challenges imposed by environmental constraints,
sustainable development, and healthier, safe and secure products add to the need of sophisticated decision making. The field of quantitative decision making in agriculture (and in lesser volume other areas) is significantly enriched by this special Handbook.

Santiago de Chile, Chile

Andres Weintraub
Preface

Many real-world decision-making situations arise from agriculture and related agri-food industries such as fisheries, water management, and irrigation. Methods and applications in Agriculture and the Agri-Food Industry are of interest at present in research developments related to the globally critical area of food production, animal welfare, and sustainability and it is expected to increase in the future. Many treatments of this subject fail to describe why and how the concerned OR methods work effectively in the context of practice. The scope of this book is to provide an overview of Operations Research (OR) methods in agriculture and a thorough discussion of derived applications in the agri-food industry. Of course, this panoramic book does not claim to offer a detailed and exhaustive view of many OR approaches to agriculture and the agri-food industry. We therefore sought high-quality works from leading researchers in the field that fit with this general scope. As Editor, I’m quite pleased with the result, which has brought together a diverse blend of research topics and modelling and solution approaches for different decisions in agriculture or in the agri-food industry.

Structure of the Book

This book represents a set of stand-alone works that introduce several OR methodologies and captures recent research trends in the application of OR methods in agriculture and the agri-food industry. In this sense, the book can be read in different ways depending on the personal interest of the reader, and so, there is not a unique recommended order for reading the different chapters. On the other hand, I’m extremely grateful to the authors for their outstanding contributions and for their patience, which have led to a final product that far exceeded my expectations.
All chapters were rigorously reviewed and I would like to thank the anonymous reviewers for their quality reviews and responsiveness.

It has been difficult to be consistent with the use of the same criteria to decide and place one chapter after the other. However, the link or connection chapter by chapter is given sometimes by the method others by the problem or field of application. Hence, the book starts with seven chapters presenting different planning problems for different agricultural products. Afterwards, three chapters making use of simulation and metaheuristics follow, before a set of five chapters dealing with problems solved using multicriteria or multiobjective related methods are presented. The last four chapters of the book are devoted to singular livestock decision problems.

Table 1 shows different characteristics of each chapter in order to help readers organize the reading of the book. Different dimensions are used to classify the content of each chapter:

- **Methodology**: Most of the chapters present and develop mixed integer linear programming models (LP) including several integer variables. The use of commercial software to solve large LP models makes this kind of applications very interesting for practical purpose. However, the adoption of these OR solutions evolves little by little. The rest of the methods employed in the book are simulation (SIM), metaheuristics (MHEU), multiobjective programming (MO), risk analysis (RA), forecasting (FOR), data envelopment analysis

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Table 1 Several characteristics of the chapters of the book
(DEA), multicriteria Analytic hierarchy process (AHP), stochastic programming (SP), and Markov decision process (MDP).

- **Decision problem**: Planning production is the problem with more applications in this book. Most of these problems are solved using LP models. Other examples of problems are decision analysis to assess either risk situations or just management alternatives, efficiency analysis, sustainability, location, the diet problem, and the replacement problem.

- **Agricultural product**: Agriculture produces a variety of products that most of them are presented in one or more chapters of this book. Pig is the most frequent product. There are also chapters dealing with fruits and vegetables, fish, seed corn, olive oil, beef, and horticulture products. It is worth mentioning that even when the described problems seem product-specific (e.g., replacement problem in pigs), the method behind has a wider application to other products/species (e.g., replacement problems in cows, sheep, or other livestock). A couple of chapters are devoted to other topics focused more on the management of natural resources like water and soil impacting on agricultural production. A chapter is devoted to soil management or how to define plots to maximize crop yielding. And another one is devoted to water management in some regions of Africa.

- **Level**: Although several problems are formulated and solved at farm level, applications at supply chain level are becoming more and more common. Furthermore, water management and risk analysis in agriculture are some agricultural problems dealt at regional or national level regularly.

- **Country**: Studies presented have been developed under specific conditions of a country that may be different country to country. There is a wide representation of applications developed in Europe and America, less in Australia and Africa, and unfortunately none from Asia.

The book is primarily a reference for researchers, Ph.D. students, instructors, and advanced practitioners. Depending on the technique, most chapters introduce briefly the method employed before tackling the agricultural problem presented. So, the book is also expected to be useful and appropriate for use as a textbook for certain advanced courses; and due to the interdisciplinary nature of the content, such courses may be taught in a variety of departments including Operations Research, Agriculture, Applied Mathematics, Agricultural or Agronomic Engineering, and Agricultural Economics or Ecosystems.

Lleida, Spain

Lluis M. Plà-Aragonés
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