

Multicriteria Model Analysis - Methodology, Application and Software

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This article summarizes 10 years activities of the Methodology of Decision Analysis (MDA) Project at IIASA. The MDA Project has aimed at exploring, developing and implementing methods of decision support for the applied research problem areas in which IIASA is active. The emphasis of the project was on formal methods of analysis and evaluation: the activities, therefore, were more of a mathematical than of a computing science nature. In the last few years, the work of the project has become more related to other IIASA activities, particularly in the environmental area.

Introduction

The Methodology of Decision Analysis Project has addressed the broad area of developing ways in which formal methods may help in preparing and supporting decision making. This area of concern is becoming more important for two main reasons. First, because all net effects of prospective decisions need to be evaluated and second, the decision making processes themselves are becoming more complex because of the involvement of numerous parties and interests. A more precise and detailed evaluation and analysis of the effects of prospective decisions needs to be made. Methods also have to be developed to support the selection of decisions. Recent progress in computation and information technology make it indeed possible to implement intelligent methods of decision support. There are several paradigms for intelligent decision support; for instance, the mathematical approach, the rule-based approach and the black box approach. However, it is not at all clear which paradigm should be used in which situation. In fact, experience indicates that quite often a combination of approaches is preferable. The research focus of the project was to investigate when and how which approach should be used.

For each of the possible approaches, fundamental research is being done in several research institutes all over the world. One aim of this project was to build a bridge between that fundamental research and IIASA's areas of application. This bridge should have two-way traffic: i.e., that theoretical and methodological work be done in an environment where many of the real problems are identified, and that IIASA have this type of in-house expertise available.

The MDA Project was discontinued at the end of 1996 but many of the activities that have proved to be useful at IIASA are being continued now within the Risk, Modeling and Policy (RMP) Project at IIASA. In Summer 1997 a new project on Decision Analysis and Support will start at IIASA new activities in the field of decision support.

Objectives

The main objective of the activities summarized here is to acquire the knowledge, methodology and tools for developing decision analysis support methods for classes of research problems within IIASA's areas of interest. Typical problem classes would be those of land use and land cover change, ozone, acid rain, and pollution in river basins. The objective is not to make tools for a particular problem, but rather to develop tools that would address a particular class of problems and that can be used as building blocks for treating a particular problem.

Approach and Activities

The central part of the Project's activities continues to be the acquisition of knowledge, methodology and tools for developing decision analytic and support methods for particular problems within IIASA's areas of interest. These activities are flanked by two other types of activities:

- (1) the implementation of decision support methods for specific problems, stemming from other IIASA projects, and

(2) exploring new methods which could be potentially useful for those projects and related problems.

Both of these activities, in turn, support the central activities. Moreover, the implementation of decision support methods is useful to obtain experience with the methodology developed in the Project and hence new activities can be triggered by any observed weak points.

Acquisition and Implementation of Knowledge, Methodology and Tools

The Project collaborates with several other IIASA projects and ongoing research in this area. The case studies are also be used for testing both the methodology and tools. We outline here several on-going and recent activities.

Research of decision support methodology in the area of land use policies is continued in collaboration with the Land-Use and Land-Cover Changes Project and with the Food and Agriculture Organization (FAO) of United Nations. Good results were obtained with an optimization method based on interior point methods and with using Multiple Criteria Model Analysis methods to the problem of Agroecological Zones.

In collaboration with the Transboundary Air Pollution Project, extensions to the existing methods will also be developed for the new versions of the RAINS model for Europe and for the RAINS model for Asia. Currently we concentrate on the development of software tools for analysis of the Ozone model (which is a large scale non-linear programming problem). Therefore the collaboration with the TAP Project will include continuation of the development and application of tools for the generation and analysis of medium and large scale optimization models, both for linear and non-linear problems.

The methodology for supporting decisions regarding water quality in river basins and a dedicated decision support system (that uses multicriteria model analysis) has been developed and applied in joint research with the Water Resources Project on the Nitra case study.

The activities of the Environmentally Compatible Energy Strategies project result in large scale, badly conditioned LP problems. The HOPDM (interior point method based LP solver) is being successfully applied to those optimization problems. That provides an opportunity for extending the collaboration to the joint research on formulation and solution techniques for the corresponding class of optimization models.

For all mentioned activities, the modeling process should be improved. Therefore, the introduction of new modeling tools in these areas will be investigated based on the progress that has been made in recent years with automatic modeling aids for optimization problems.

Further improvements of multicriteria model analysis for decision support and modular solvers for different types of optimization problems has been done in recent years. The long-term collaboration with a group of researchers in Poland and with several IIASA projects is being summarized in the form a book and several modular software packages. The software is available free of charge for research and educational purposes and there are already several hundreds of users of this software world-wide. The software is available through the Web (please see URL: <http://www.iiasa.ac.at/~marek> for details).

Long term collaboration with the Japanese Research Institutions provides also real-world case studies for methodology and software for model based decision support. In recent years this collaboration has concentrated on development of a computer simulation model to estimate impacts of climate change by the greenhouse effect on agricultural production and arable land-use, and the use of this model to predict these impacts in the Asia-Pacific region. The aim of this research is to quantitatively analyze the current demand and supply situation between funding agencies and research institutes and to also clarify the future balance between this kind of demand and supply. This research results is recommendation of the most efficient ways of promoting global environmental research for the research institutes. It is conducted in collaboration with several relevant organizations such as: the Asia-Pacific Network for Global Change Research (APN), the International Group of Funding Agencies for Global Change Research (IGFA), and the START Regional Committees. This research is done in a close collaboration with the National Institute for Environmental Studies (NIES) in Japan and with the LUC project at IIASA.

The usefulness of neural nets for decision support has been investigated in cooperation with the Vienna University of Economics and Business Administration and with the Technical University of Eindhoven, The Netherlands. The Austrian Ministry for Sciences, Research and the Arts awarded funds for this activity. The purpose of the study was twofold: first, to develop a prototype neurocomputing architecture for the analysis of satellite data in order to identify the type of land-use, and second, to compare the performance of the prototype architecture with existing statistical techniques.

Workshops

Since 1987 the annual workshop on Advances of Methodology and Software for Decision Support is organized in cooperation with Professor Y. Sawaragi, Chairman of the Japan Institute of Systems Research. Each year about 40 researcher and practitioners meet at IIASA to review advances of decision support methodology and its applications to real-world problems.

Several smaller workshops have been organized on specific topics of methodology and modeling for decision support. The abstracts of workshops organized after 1995 and the information about currently organized workshops are available on the Web.

Results and Applications

Selected, primarily methodological, results were submitted to refereed journals. Other results were published as IIASA Working Papers. An edited volume on methodology, software and applications of Decision Support Systems which summarizes the last few years of research will be completed in 1997. The list of publications is available on the IIASA's Web, many of these publications are available in electronic form on-line.

Several modular software packages are also available through the Web, free of charge for research and educational purposes. This includes:

MCMA: Modular tool for multicriteria model analysis. This includes the tools developed in recent years LP-DIT (Linear Programming Data Interchange Tool), LP-MULTI (a modular utility for generation of multicriteria problems) and ISAAP (a utility for interactive specification and analysis of aspiration-based user preferences, with optional interpretation in terms of fuzzy sets).

Solvers for linear programming and mixed integer programming problems developed in the last few years in collaboration with Polish researchers.

The software and its documentation (as well as access to the publications available on-line, and information about current activities, and about selected past activities) can be found at the URL:

<http://www.iiasa.ac.at/~marek>