Decision Support Systems: an Overview

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Decision Support System in Agriculture Using Quantitative Analysis

Edited By

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About the Book

With the advances in data generation, collection and storage technology the world is overwhelmed with data everywhere. Following this trend, more and more agricultural data is being collected and stored in databases. As the volume of the data increases, the gap between the amount of the data stored and the amount of the data used for analysis also increase. The data can be used in productive decision making if appropriate economic tools are applied. The present book on "Decision Support System in Agriculture Using Quantitative Techniques" is conceived with an idea to provide insight to the readers about the enormous potential of analytical tools and to explore it in the area of agriculture. The researchers can apply the techniques to data sets from their respective domains and build the model which can help in forecasting, prediction, classification or decision making. An overview of open source R-software is also provided to implement the analytical techniques. It aims to achieve the followingobjectives: 1.To improve understanding of the basic concepts and tools for socio-economic and agricultural data management and analysis for taking decisions in agriculture based on large data sets. 2. To sensitize and expose readers to various econometric methods and models for agricultural decision making.

This book presents recent advances inMethods for efficient data storage, management, retrieval, Quantitative and analytical tools used in agricultural decision making, linear and nonlinear models and estimation techniques. Cross-section and time series data analysisetc.

The book is a tool of information that will serve the readers to keep abreast of knowledge and techniques in this broad field. The book also is an inspiration for further theoretical and practical pursuits which will open up exciting opportunities for analysing data in newer ways.

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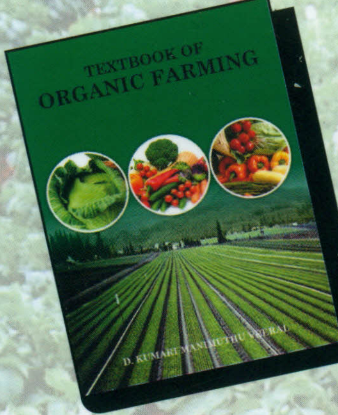

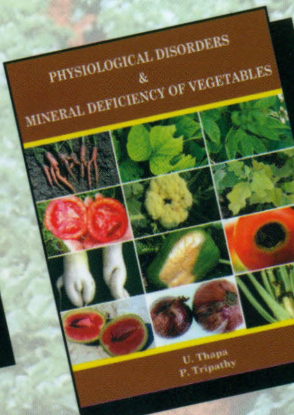

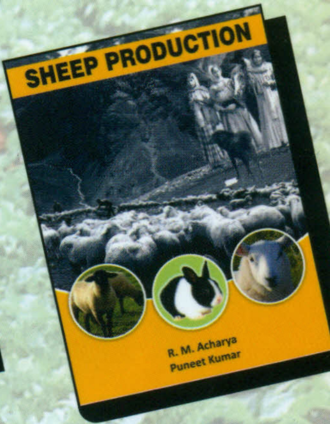

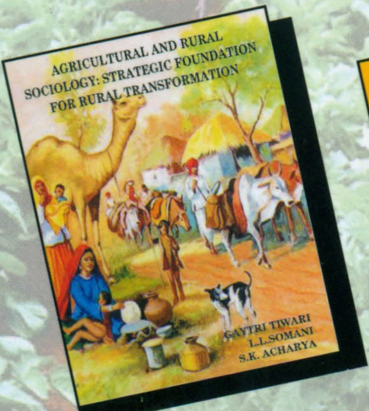

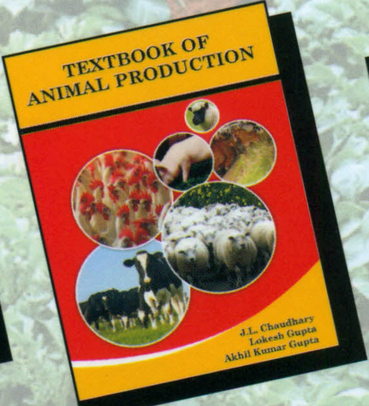

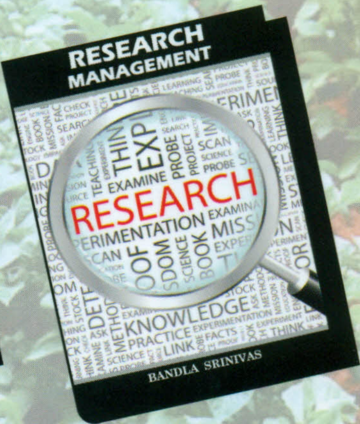

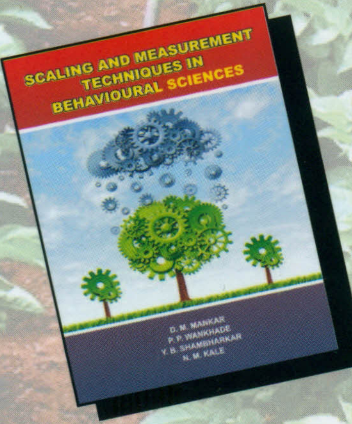

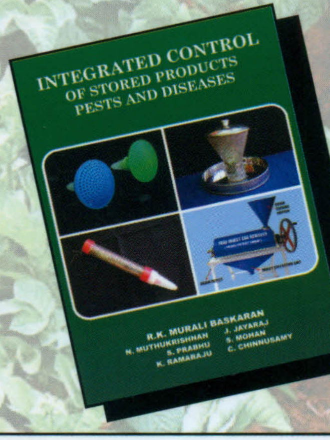

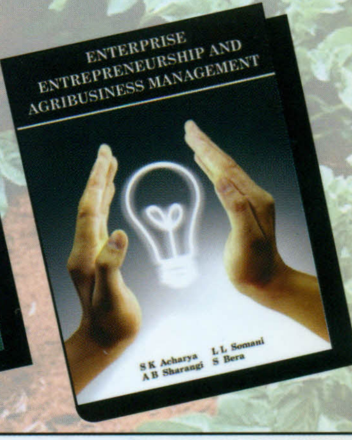

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PREFACE

The book titled "Decision Support System in Agriculture using Quantitative Analysis" provides a summary of themethods and quantitative techniques used by professionals for Decision Support System in Agriculture. The book is divided in 23 chapters. Each chapter has been developed based on the presentation by the respective authors in training programmeto the faculty working in the areas of agricultural research. However, the quantitative techniques covered are useful for the scholars working in other domains also.

The book is different from other books on quantitative analysis in many aspects. Some books cover quantitative techniques in theoretical sense. Some other books cover practical aspects of a single issue without the emphasis on quantitative analysis. However, the applications of quantitative techniques presented in the book are based on actual research, several years of experience of the authors and the actual datasets rather than hypothetical ones. Hence the chapters offer real problems and the solutions while using the specified quantitative technique. Further, the book provides a comprehensive overview of R Software, open source free software for using a quantitative analysis. GIS and remote Sensing are emerging tools for modern research. Chapter 13 and Chapter 23 provide enough coverage of the techniques to sensitize the modern researcher regarding exploration on possible applications of these techniques.

We take this opportunity to gratefully acknowledge the contribution made bythe authors of various papers in the preparation of this book. We warmly acknowledge the varioussources and publications from which valuable materials for this book has been drawn.

We sincerely acknowledge the help and guidance received fromProf. Ramesh Chand, Director, ICAR-National Centre for Agricultural Economics and Policy Research, New Delhi who encouraged and provided institutional facilities in preparation of the book. We acknowledge the financial help received from Education Division, ICAR in organizing the Summer School on “Decision Support System in Agriculture Using Quantitative Techniques”.

Wealso take this opportunity to express oursincere thanks and gratitude to all who have made valuable suggestions to enhancethe utility of the book and also wish to acknowledge and express our sincere thanksand gratitude to Prof. L.L.Somani, Ex -Director, Resident Instructions, M.P., University of Agriculture and Technology, Udaipur for providing the necessaryencouragement to complete this book.

Editors

Rajni Jainand SS Raju

About the Book

With the advances in data generation, collection and storage technology the world is overwhelmed with data everywhere. Following this trend, more and more agricultural data is being collected and stored in databases. As the volume of the data increases, the gap between the amount of the data stored and the amount of the data used for analysis also increase. The data can be used in productive decision making if appropriate economic tools are applied. The present book on "Decision Support System in Agriculture Using Quantitative Techniques" is conceived with an idea to provide insight to the readers about the enormous potential of analytical tools and to explore it in the area of agriculture. The researchers can apply the techniques to data sets from their respective domains and build the model which can help in forecasting, prediction, classification or decision making. An overview of open source R-software is also provided to implement the analytical techniques. It aims to achieve the followingobjectives: 1.To improve understanding of the basic concepts and tools for socio-economic and agricultural data management and analysis for taking decisions in agriculture based on large data sets. 2. To sensitize and expose readers to various econometric methods and models for agricultural decision making.

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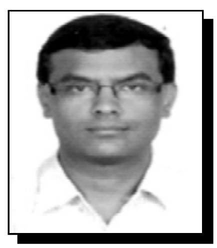
About the Editors

Dr.Rajni Jain is currently working as Principal Scientist, Computer Applications in Agriculture at ICAR-National Centre for Agricultural Economics and Policy Research since 1996. She was awarded Ph.D. degree in Computer Science from Jawaharlal Nehru University in 2005 in the area of data mining and M.Sc. degree in the discipline of Computer Application from Post Graduate School, Indian Agricultural Research Institute in 1991 with a gold medal for her outstanding academic performance. Rajni made important and useful contributions to the discipline of agricultural economics by planning, design and development of many online software and data mining based models for agriculture. Her research interests include development of decision support systems for agriculture domain using data mining techniques. Rajni Jain has contributed nearly80 research papers in journals, conferences, workshops and seminars. Besides she has organised many training programmes for the researchers in national agricultural research system. she can be reached at rajni@ncap.res.in



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on regional crop planning, agricultural risk and insurance, biofuels and energy use in agriculture, livestock and growth and development. Dr. Raju is author of one book and 30 research papers published in reputed national and international journals. He was associated with 10 national and international research projects. He can be reached at raju@ncap.res.in.

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Decision Support Systems: An Overview

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Introduction

A Decision Support System (DSS) is a computer-based information system that supports business or organizational decision-making activities. DSSs serve the management, operations, and planning levels of an organization and help to make decisions, which may be rapidly changing and not easily specified in advance. DSSs include knowledge-based systems. A properly designed DSS is an interactive software-based system intended to help decision makers compile useful information from a combination of raw data, documents, personal knowledge, or business models to identify and solve problems and make decisions. Typical information that a decision support application might gather and present are inventories of information assets including legacy and relational data sources, cubes, data warehouses, data marts, comparative production figures between one period and the next or the projected revenue figures based on production and demand assumptions.

Review

According to Keen (1978), the concept of decision support has evolved from two main areas of research: the theoretical studies of organizational decision making done at the Carnegie Institute of Technology during the late 1950s and early

1960s, and the technical work on interactive computer systems, mainly carried out at the Massachusetts Institute of Technology in the 1960s (Keen, 1978). It is considered that the concept of DSS became an area of research of its own in the middle of the 1970s, before gaining in intensity during the 1980s. In the middle and late 1980s, executive information systems (EIS), group decision support systems (GDSS), and organizational decision support systems (ODSS) evolved from the single user and model-oriented DSS.

The definition and scope of DSS has been migrating over the years (Efraim et. al, 2008). In the 1970s DSS was described as “a computer based system to aid decision making”. Late 1970s the DSS movement started focusing on “interactive computer-based systems which help decision-makers utilize data bases and models to solve ill-structured problems”. In the 1980s DSS should provide systems “using suitable and available technology to improve effectiveness of managerial and professional activities”, and late 1980s DSS faced a new challenge towards the design of intelligent workstations.

In 1987 Texas Instruments completed development of the Gate Assignment Display System (GADS) for United Airlines. This decision support system is credited with significantly reducing travel delays by aiding the management of ground operations at various airports, beginning with O’Hare International Airport in Chicago and Stapleton Airport in Denver Colorado (Efraim et. al, 2008).

Beginning in about 1990, data warehousing and on-line analytical processing (OLAP) began broadening the realm of DSS. As the turn of the millennium approached, new web-based analytical applications were introduced. The advent of better and better reporting technologies has seen DSS start to emerge as a critical component of management design. Examples of this can be seen in the intense amount of discussion of DSS in the education environment.

DSS also have a weak connection to the user interface paradigm of hypertext. Both the University of Vermont (PROMIS system for medical decision making) and the Carnegie Mellon (ZOG/KMS system for military and business decision making) were decision support systems which also were major breakthroughs in user interface research. Furthermore, although hypertext researchers have generally been concerned with information overload, certain researchers, notably Douglas Engelbart, have been focused on decision makers in particular.

Architecture

Four fundamental components of a DSS architecture (Sprague1982; Haag, 2000; Marakas, 1999) are: (1) The database (or knowledge base), (2) The model (i.e., the decision context and user criteria), (3) The user interface and (4) Users

A database is an organized collection of data for one or more purposes, usually in digital form. The data are typically organized to model relevant aspects of reality (for example, the availability of rooms in hotels), in a way that supports processes requiring this information (for example, finding a hotel with vacancies). The term "database" refers both to the way its users view it, and to the logical and physical materialization of its data, content, in files, computer memory, and computer data storage. This definition is very general, and is independent of the technology used. However, not every collection of data is a database; the term database implies that the data is managed to some level of quality (measured in terms of accuracy, availability, usability, and resilience) and this in turn often implies the use of a general-purpose Database management system (DBMS). A general-purpose DBMS is typically a complex software system that meets many usage requirements, and the databases that it maintains are often large and complex. Some examples are oracle DBMS, Access and SQL Server from Microsoft, DB2 from IBM and the Open source DBMS MySQL.

In the most general sense, a model is anything used in any way to represent anything else. Some models are physical objects, for instance, a toy model which may be assembled, and may even be made to work like the object it represents. They are used to help us know and understand the subject matter they represent. The term conceptual model may be used to refer to models which are represented by concepts or related concepts which are formed after a conceptualization process in the mind. Conceptual models represent human intentions or semantics. Conceptualization from observation of physical existence and conceptual modeling are the necessary means human employ to think and solve problems.

A user interface is the system by which people (users) interact with a machine. The user interface includes hardware (physical) and software (logical) components. User interfaces exist for various systems, and provide a means of: Input, allowing the users to manipulate a system, and/or Output, allowing the system to indicate the effects of the users' manipulation. The users themselves are also important components of the architecture.

Benefits of DSS

Any DSS aims to provide benefits to the users of various levels as follows:

1. Improves personal efficiency
2. Speed up the process of decision making
3. Increases organizational control
4. Encourages exploration and discovery on the part of the decision maker

5. Speeds up problem solving in an organization
6. Facilitates interpersonal communication
7. Promotes learning or training
8. Generates new evidence in support of a decision
9. Creates a competitive advantage over competition
10. Reveals new approaches to thinking about the problem space
11. Helps automate managerial processes

Taxonomy

There are several ways to classify DSS applications. Not every DSS fits neatly into one of the categories, but may be a mix of two or more architectures. As with the definition, there is no universally-accepted taxonomy of DSS either. Different authors propose different classifications. The three taxonomies that are mentioned in this paper are based on relationship with the user as the criterion, using the mode of assistance as the criterion, using scope as the criterion, and using framework as a criterion.

Using the relationship with the user as the criterion, differentiates *passive*, *active*, and *cooperative DSS* (http://www.decision-making-confidence.com/). A *passive DSS* is a system that aids the process of decision making, but that cannot bring out explicit decision suggestions or solutions. An *active DSS* can bring out such decision suggestions or solutions. A *cooperative DSS* allows the decision maker (or its advisor) to modify, complete, or refine the decision suggestions provided by the system, before sending them back to the system for validation. The system again improves, completes, and refines the suggestions of the decision maker and sends them back to him for validation. The whole process then starts again, until a consolidated solution is generated.

Another taxonomy for DSS has been created by Daniel Power. Using the mode of assistance as the criterion, Power differentiates *communication-driven DSS*, *data-driven DSS*, *document-driven DSS*, *knowledge-driven DSS*, and *model-driven DSS* (Power, 2002; Power, 1997). A communication-driven DSS supports more than one person working on a shared task; examples include integrated tools like Microsoft's NetMeeting or Groove (Stanhope, 2002). A data-driven DSS or data-oriented DSS emphasizes access to and manipulation of a time series of internal company data and, sometimes, external data. A document-driven DSS manages, retrieves, and manipulates unstructured information in a variety of electronic formats. A knowledge-driven

DSS provides specialized problem-solving expertise stored as facts, rules, procedures, or in similar structures (Power, 2002). A model-driven DSS emphasizes access to and manipulation of a statistical, financial, optimization, or simulation model. Model-driven DSS use data and parameters provided by users to assist decision makers in analyzing a situation; they are not necessarily data-intensive. Dicodess is an example of an open source model-driven DSS generator (Gachet, 2004).

Using scope as the criterion, Power differentiates *enterprise-wide DSS* and *desktop DSS*. An *enterprise-wide DSS* is linked to large data warehouses and serves many managers in the company (Power, 1997). A *desktop, single-user DSS* is a small system that runs on an individual manager's PC.

Some authors classify DSS into the following six frameworks: Text-oriented DSS, Database-oriented DSS, Spreadsheet-oriented DSS, Solver-oriented DSS, Rule-oriented DSS, and Compound DSS (Hollsopple et. al., 2013). A compound DSS is the most popular classification for a DSS. It is a hybrid system that includes two or more of the five basic structures described above (Hollsopple et. al., 2013). The support given by DSS can be separated into three distinct, interrelated categories: Personal Support, Group Support, and Organizational Support (Hackathorn, 1981). For all kinds of DSS, there are four major components. The DSS components may be classified as:

1. **Inputs:** Factors, numbers, and characteristics to analyze
2. **User Knowledge and Expertise:** Inputs requiring manual analysis by the user
3. **Outputs:** Transformed data from which DSS "decisions" are generated
4. **Decisions:** Results generated by the DSS based on user criteria

DSS is a Management level computer system that combines data, models and user friendly software for semi-structured and unstructured decision making. Central Issue in DSS is to provide support and improvement of decision making. Sometimes, it is controversial and confusing to decide whether outcome of a quantitative technique or a computer based information system to be called a DSS or not. As per popular opinion, any system will be considered a DSS if it helps in decision making. The extent may vary from one to the other. Thus DSS may be categorized into one of the following types:

1. MODEL DRIVEN DSS: Uses models for what-if and other analysis
2. DATA-DRIVEN DSS: Allows extraction, analysis of information from databases

3. **COMMUNICATION DRIVEN DSS: uses network and communications technologies to facilitate decision-relevant collaboration and communication**
4. **DOCUMENT DRIVEN DSS: A document-driven DSS uses computer storage and processing technologies to provide document retrieval and analysis**
5. **KNOWLEDGE DRIVEN DSS: suggest or recommend actions to managers**
6. **WEB-BASED DSS: delivers decision support information or decision support tools to a manager or business analyst using a "thin-client" Web browser like Netscape Navigator or Internet Explorer**
7. **Hybrid DSS: Combination of one or more**

DSS in India

Development of many DSS has been attempted in National Agricultural Research System. (Shinoj et. al.) is an example of model driven DSS developed at NCAP under NAIP. CMOStat (Jain et. al., 2012) is an example of data driven DSS. E-Sagu (http://www.esagu.in/) is an IT-based personalized and scalable agro-advisory system with an aim to improve farm productivity, profitability and sustainability by delivering agro-expert advice in a timely manner to each farm at the farmer's door-steps. E-Sagu can be categorized into communication driven DSS. CeRA (http://www.CeRA.iari.res.in) is an example of a document driven DSS. Expert system of a crop or a specific domain is an example of knowledge driven DSS e.g. expert system of wheat or an expert system of maize developed by IASRI and DMR respectively. (http://www.iasri.res.in/expert/). WBSTFP and RuleGen (Jain et. al, 2011; Jain et. al, 2013a, Jain et. al, 2013b) are web based DSS. Normally DSS are not based on only one resource i.e. data or document or web but requires combination of more than one category of resources and are referred as Hybrid DSS. A study of the websites and annual reports of ICAR institutes shows that most of the institutes having some DSS is of the data driven, web based, communication driven type DSS. Model driven DSS are negligible in NARS and requires attention. DSSAT4 is a typical DSS mentioned briefly in next section (http://dssat.net/).

DSSAT4: A Global example of DSS

There are theoretical possibilities of building decision support systems in any knowledge domain. Decision support system for medical diagnosis is one such example. Other examples include a bank loan officer verifying the credit of a loan applicant or an engineering firm that has bids on several projects and wants to know if they can be competitive with their costs. DSS is extensively used in business and management. Executive dashboard and other business performance software allow faster decision making, identification of negative trends, and better allocation of business resources. DSS are also prevalent in forest management where the long planning time frame demands specific requirements. All aspects of Forest management, from log transportation, harvest scheduling to sustainability and ecosystem protection have been addressed by modern DSSs. A specific example concerns the Canadian National Railway system (CNRS), which tests its equipment on a regular basis using a decision support system. A problem faced by any railroad is worn-out or defective rails, which can result in hundreds of derailments per year. Under a DSS, CNRS managed to decrease the incidence of derailments at the same time other companies were experiencing an increase.

A growing area of DSS application, concepts, principles, and techniques is in agricultural production, marketing for sustainable development. For example, the DSSAT4 package (http://www.aglearn.net/resources/isfm/DSSAT.pdf) developed through financial support of USAID during the 80's and 90's, has allowed rapid assessment of several agricultural production systems around the world to facilitate decision-making at the farm and policy levels. There are, however, many constraints to the successful adoption on DSS in agriculture (Stephens et. al, 2002).

The Decision Support System for Agrotechnology Transfer (DSSAT4) is a software package integrating the effects of soil, crop phenotype, weather and management options that allows users to ask "what if" questions and simulate results by conducting, in minutes on a desktop computer, experiments which would consume a significant part of an agronomist's career. It has been in use for more than 15 years by researchers in over 100 countries. DSSAT is a microcomputer software product that combines crop, soil and weather data bases into standard formats for access by crop models and application programs. The user can then simulate multi-year outcomes of crop management strategies for different crops at any location in the world.

DSSAT also provides for validation of crop model outputs; thus allowing users to compare simulated outcomes with observed results. Crop model validation is accomplished by inputting the user's minimum data, running the model, and comparing outputs. By simulating probable outcomes of crop management strategies, DSSAT offers users information with which to rapidly appraise new crops, products, and practices for adoption.

Summary

The article covers the history, architecture and taxonomy of various types of DSS. It further makes mention of a few efforts in DSS development in India and

abroad. It is visible that our country requires more consistent efforts in building model driven DSS which will further require appropriate training and development of skills.

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