

RESEARCH INSTITUTE
FOR SOIL SCIENCE
AND AGROCHEMISTRY,
BUCHAREST
Computing Centre

JOINT RESEARCH CENTRE of the C.E.
ISPRA,
Institute for Remote Sensing Applications,
Agricultural Information Systems Unit

INTEGRATION OF AN EXPERT SYSTEM IN A G.I.S. FOR AGRICULTURE

by
Virgil VLAD

(Final Report of the contract No. CIPA-CT-93-2350 / CEC-DG12-HSMU)

December 1994

COMMISSION OF THE EUROPEAN COMMUNITIES

CONTENTS

1. Introduction	3
2. Land Evaluation. Concepts and Methods.	7
2.1. <i>Objectives of Land Evaluation</i>	7
2.2. <i>Principles of Land Evaluation</i>	8
2.3. <i>Levels of Land Evaluation</i>	8
2.4. <i>Other concepts</i>	10
2.5. <i>Methods for Land Evaluation</i>	12
3. Present Land/Soil Data and Land Evaluation in Romania	17
3.1. <i>The Romanian Land Evaluation Methodology for 1:10000 scale</i>	17
3.2. <i>The Available Land/Soil Data</i>	20
3.2.1. Land/Soil Data Bases	20
3.2.1.1. Soil Profiles Data Base	20
3.2.1.2. Data Bases of Land Units	21
3.2.1.3. Data Base of Soil Quality Monitoring	25
3.2.2. Experimental Geographic Information System	25
3.2.3. Land/Soil Data and Maps	25
3.3. <i>Other Data Processing</i>	26
3.3.1. Pedo-Transfer Functions	26
3.3.2. SIBIL Simulation Model	26
3.3.3. Technological Recommendations for Soil Works	28
3.3.4. SOFIA – Recommendations for Fertiliser and Lime Materials Use	28
3.3.5. ELTEC – Computer Aided Design for Annual Crop Technologies	28
4. Requirements for a new Land Evaluation System in Romania	29
5. Feasibility of Using Deterministic Models	
with Available Romanian Land/Soil Data for Land Evaluation	31
6. Requirements for the Romanian Land/Soil Geographic Information System	49
6.1. <i>General Presentation</i>	49
6.2. <i>Requirements for the Land/Soil GIS</i>	50
7. General Structure of the new Land Evaluation System in Romania	51
7.1. <i>General Structure of the new Land Evaluation System in Romania</i>	51
7.2. <i>Computer Implementation of the Land Evaluation Integrated Expert System</i>	52
8. General Structure of the Land/Soil Geographic Information System	55
8.1. <i>Data Structures for the Land/Soil GIS</i>	55
8.2. <i>Computer Implementation of the Land/Soil GIS</i>	57
8.2.1. Implementation Strategy	57
8.2.2. Software Requirements	58
8.2.3. Software Configuration	58
8.2.4. Hardware Configuration	58
9. Conclusions	61
10. References	63
Appendix 1. Land Characteristics Definition in the Romanian Land Evaluation Methodology for the 1:10000 scale	75
Appendix 2. WOFOST Soil Data Files for the Romanian Soil Physical Groups	79
Appendix 3. Meteorological data (WOFOST Climate Format) for Romanian Meteo Stations	83
Appendix 4. WOFOST Crop Files	85
Appendix 5. Example of WOFOST Output	91

INTRODUCTION

This report presents the research work carried out by the author in the Joint Research Centre of the European Communities (JRC-Ispra) – Institute for Remote Sensing Applications – Agricultural Information Systems Unit in the period 13 September – 12 December 1994.

The work was sponsored by the European Economic Community (the Commission of the European Communities) under the contract no. CIPA-CT-93-2350 (DCG 12 HSMU) within the framework “Cooperation in Science and Technology with Central and Eastern European Countries-Action 3.A (Mobility Scheme)”

The author thanks the staff of the Agricultural Information Systems Unit of the Institute for Remote Sensing Application for the help given in carrying out of the work. Special acknowledgements are due to Anne Burrill and Vanda Perdigao who supervised the work, Paul Vossen, Tamme van der Wal, Jean-Francois Dallemand, Jurgen Vogt, Pascal Jacques and Thierry Maucq for their advices, suggestions and aid in documentation.

The author thanks Graeme Wilkinson (EMAP Unit, Institute for Remote Sensing Applications of JRC), Palle Haastrup (Technology Assessment Sector, Institute for Systems Engineering and Informatics of JRC) and Cees A. van Diepen (Land Inventory and Land Evaluation Division, Winand Staring Centre for Integrated Land, Soil and Water Research – Wageningen) for useful discussions, suggestions and aid in documentation. A particular acknowledgement is due to Prof. Willy H. Verheye (Soil Department University of Gent, National Science Foundation of Belgium) and Prof. Michel-Claude Girard (Soil and Hydrology Department, Agronomic National Institute Paris-Grignon) for their aid in documentation.

Also, the author thanks Prof. Corneliu Rauta, Mihail Dumitru, Andrei Canarache, Catalin Simota, Ion Munteanu, Stelian Carstea, Ruxandra Vintila (all from Research Institute for Soil Science and Agrochemistry-Bucharest) and Corneliu Vasile (Institute for Agricultural Economy-Bucharest) for their help in carrying out of this work.

In the last years, the new requirements arisen for the decision-makers in the domain of agriculture and the progress obtained in the fields of the agricultural sciences and information technology have led, among others, to the development of the geographic information systems for the management and processing of the spatial-referenced agricultural data, the expert systems and new methods for land evaluation.

Research Institute for Soil Science and Agrochemistry-Bucharest has the responsibility and has elaborated for Romania methodologies (models) for agricultural land evaluation and soil protection/conservation and reclamation, as well as data bases concerning land/soil resources (scales – 1:10.000, 1:50.000, 1:200.000, 1:1.000.000). These are – in some respects – different from those of the European Communities. The computer implementation of these methodologies (models) and data bases was accomplished in classical manner.

The research programmes of the institute include the elaboration of land/soil expert systems and a geographic information system (GIS) for agricultural land/soil of Romania.

The general objectives of this work consisted of:

(1) Establishing the conception and requirements of an Expert System for agricultural land evaluation and technological recommendations concerning soil protection/conservation and reclamation, and of a Geographic Information System for Romanian agricultural land/soil, taking into consideration:

- present needs and realities;
- the specificity of the Romanian lands/soils and Romanian agricultural technological and economic systems;
- the existing Romanian agricultural data bases;
- the necessity of the compatibility with the systems of the European Communities (e.g. MARS and CORINE projects).

(2) Establishing the structure (data and functions/modules) of the two systems and the way to integrate them. Establishing the way to implement on computer their structures (methods and tools; hardware and software requirements).

CONCLUSIONS

In this work, the following main actions were accomplished:

- 1) Analysis of the concepts and methods concerning agricultural land evaluation, obtaining:
 - . a coherent system of the Land Evaluation definition (objectives, principles, levels, main elements, classification),
 - . classification of the methods used for Land Evaluation,
 - . an analysis of these methods (advantages and disadvantages).
- 2) Analysis of the Romanian Land Evaluation Methodology used at present:
 - . a synthetical presentation of the methodology and its implementation (ExET) using an expert system shell (ALES),
 - . advantages and disadvantages of this implementation.
- 3) Analysis of the land/soil data – descriptive (data bases) and spatial (maps) – existing in Romania at present: This analysis pointed out:
 - . the positive elements (large volumes of data, detailed-enough level of data),
 - . the negative elements (great variety of data types/methodologies, lack of more detailed meteorological data, non-compatibility with the European and other methodologies, lack of digitized maps).
- 4) Analysis of the computerized land/soil data processing in Romania, which pointed out:
 - . good pedo-transfer function (calibrated for Romanian conditions),
 - . advances in soil water flow and crop growth simulation modelling,
 - . good experience in advanced land/soil data processing.
- 5) Establishing the general requirements for a new Land Evaluation System in Romania – from the functional and operational point of view.
- 6) Analysis of the feasibility of the use a deterministic crop growth simulation model (WOFOST¹) with the available Romanian land/soil data at large scale in the purpose of land evaluation:
 - . establishing of general methods for obtaining of the input data for the WOFOST model from the available Romanian land/soil data,
 - . establishing of general methods for comparison of the results obtained by the two ways of land evaluation: simulation based on a deterministic model (quantitative land evaluation) and semi-quantitative land evaluation based on a expert system (ExET) which implements the Romanian land evaluation methodology for the 1:10.000 scale: three land evaluation (suitability) indexes were defined for the two cases,
 - . the experiments proved the feasibility of the proposed quantitative land evaluation method.
- 7) Establishing the general requirements for the Romanian Land/Soil Geographic Information System.

¹ The WOFOST model was developed at the Winand Staring Centre for Integrated Land, Soil and Water Research Wageningen and is used by the Agricultural Information Systems Unit of IRSA/JRC in the Crop Growth Monitoring System (CGMS) for crop state assessment and yield forecast (MARS Project).

- 8) Establishing of the general structure of a new land evaluation system in Romania:
 - . a new approach – the “integrated expert system” using a “models base”,
 - . the interface (integration) with the Land/Soil GIS,
 - . the general principles, the way and the software tools for computer implementation;

- 9) Establishing the general structure of the Land/Soil Geographic Information System in Romania:
 - . the data structures (layers and hierarchical attribute tables),
 - . the interface (integration) with land evaluation system,
 - . the general principles of the computer implementation,
 - . the requirements for GIS software,
 - . software and hardware configuration.

For the requirements, analysis and system conception, the top-down approach was used. Following this approach, further requirements analysis and systems conception must be carried out gradually on more detailed levels:

- more detailed analysis of the concrete utilization of the two systems (Land Evaluation Integrated Expert System and Land/Soil Geographic Information System) and of the available data; corresponding to the analysis results, the detailed function of the systems can be established (land utilization types, land suitability types, GIS layers, etc.);
- choosing the simulation models to be used for land evaluation; appropriate experiments are needed for this;
- establishing the pedotransfer functions, indirect data estimation algorithms, data converters and data generators necessary for the chosen simulation models;
- establishing the methods and carrying out the experiments necessary for obtaining the unavailable pedotransfer functions and indirect data estimation algorithms;
- establishing the methods and carrying out the experiment necessary to calibrate and validate the chosen simulation models;
- establishing the expert rules necessary for land evaluation and technological recommendations;
- establishing the data presentation features;
- establishing the priorities for the implementation of different layers of the Land/Soil GIS;
- establishing the project requirements and planning (common project for the two systems);
- establishing the working standards and procedures for the project team.

EUROPEAN COMMISSION
Directorate-General XII (Science, Research and Development)



**JOINT
RESEARCH
CENTRE**

Institute for Remote Sensing Applications
Agricultural Information Systems Unit (MARS Project)

Ispra Establishment
I-21020 Ispra (Va), Italy
Switchboard: +39 332 789111
Telex: 380042 / 380058 EUR I
Fax: +39 332 789074
Direct Phone: +39 332 785309
e_mail: a_burrill@jrc.it (Internet)

MEMO
27 Jan. 1995

To: Ms. Raendonck, DG XII⁴B
From: Anne Burrill *Burrill*
cc: The Director, ICPA, Bucharest
P. Vossen, Head of Unit, AIS/IRSA/JRC
✓ V. Vlad

Re: Contract CIPA-CT-93-2350

We have received the final report on the above referenced contract from Mr. Virgil Vlad of the Research Institute for Soil Science and Agrochemistry in Bucharest, Romania. The report presents the work carried out by the author during his three month visit to our unit in Ispra.

During this period, Mr. Vlad managed to compile a wide range of information related to techniques and tools for land evaluation. From this basis, he undertook a thorough analysis of the Romanian requirements and an assessment of the suitability and reliability of different techniques to meet these needs, including trial runs of the WOFOST model using Romanian input data. The result is a proposal for an integrated system combining various models and database management tools within an expert system structure.

Mr. Vlad's work during his visit and his report are of a high professional standard. The results should be directly applicable in Romania and might serve as a model for activities in other countries with similar needs and requirements.

*O lucrare ce ar
trebui cunoscută de
specialiștii interesați în
domeniul tratat.*

09.02.1995

Prodan