MICROLEIS 3.2: A SET OF COMPUTER PROGRAMS, STATISTICAL MODELS AND EXPERT SYSTEMS FOR LAND EVALUATION

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SUMMARY

Introduction

Although increasing consideration is being given to agricultural diversification and to lower input agriculture, it is still important to identify optimum land use systems for resource sustainability and environmental quality. Land evaluation makes it possible to use land according to its potential. During the last few years, increasing application of information technology to land evaluation procedures has led to the development of land evaluation information systems. For these computerised applications, the microcomputer (PC platform) has become an essential tool.

Since 1975, several land evaluation projects have been developed by the Instituto de Recursos Naturales y Agrobiologia, Sevilla (formerly, Centro de Edafologia y Biologia Aplicada del Cuarto), and the Agencia de Medio Ambiente, Junta de Andalucia, Spain. MicroLEIS is based on the results of these projects.

The principal objective of MicroLEIS was to establish an interactive and user-friendly system for the optimal allocation of land use and management systems under Mediterranean agroforestry conditions. The MicroLEIS system must be considered a tool for land use planning rather than an accurate predictive model.

The basic framework

The framework of MicroLEIS is in accordance with the FAO Framework for Land Evaluation with adaptations established for the European Community, and integrates land evaluation methods previously developed. Several land capability, suitability, yield prediction and vulnerability methods may be automatically applied. MicroLEIS addresses land evaluation at various scales: reconnaissance, semi-detailed and detailed, in an interrelated manner. Biophysical land evaluation procedures are combined using corresponding scale-appropriate models, which vary from purely qualitative through semi-quantitative to quantitative empirical models. Economic attributes were not considered. The ultimate output of the system is the classification of a specific soil in relation to a particular agricultural or forestry use, as well as the environmental impact assessment for sustainable land management in the Mediterranean.

General land capability

The general land capability module (named Cervatana) represents a qualitative land evaluation method as a first stage to screen land units as suitable or not suitable for agricultural use. The module rates capability according to limitations imposed by:

a) site factors: slope;
b) soil factors: useful depth, texture, stoniness, drainage and salinity;
c) erosion risk: slope, soil erodibility, rainfall erosivity and vegetation density;
d) bioclimatic deficiency: moisture degree and frost risks.

Matching-tables were used to express inferences and define, by the maximum limitation method, four capability classes: Class S1-excellent; Class S2-good; Class S3-moderate; and Class N-marginal and unsuitable. Four subclasses are also defined according to site (t), soil (l), erosion risk (r) and bioclimatic deficiency (b) limitations.

Forestry land suitability

The forestry land suitability module (named Sierra) describes the land requirements of 22 representative tree species. The land use requirements were estimated as the

minimum conditions necessary for the successful and sustained growth of a given species, according to limitations imposed by:

a) site factors: latitude, altitude, physiographic position;
b) soil factors: useful depth, texture, drainage, pH;
c) climate factors: minimum and maximum temperature, precipitation.

These land requirements were structured so that a land suitability classification could be used to indicate whether a land unit was suitable (Order S) or not suitable (Order N) for the tree species under consideration. Maximum limitation procedures were followed to establish the physical suitability method for forest use.

Agricultural soil suitability

The soil suitability module (named Almagra) was based on an analysis of edaphic factors which influence the productive growth of twelve traditional crops: wheat, corn (maize), melon, potato, soybean, cotton, sunflower, sugar-beet, alfalfa, peach, citrus and olive. Effective depth (p), texture (t), drainage (d), carbonate content (c), salinity (s), sodium saturation (a) and soil profile development (g) are the soil characteristics considered as diagnostic criteria. For each soil characteristic, a gradation matrix was established which relates the soil characteristic value to the corresponding soil crop requirements. Following the maximum limitation procedure, five relative suitability classes are determined: Class S1-very high, Class S2-high, Class S3-moderate, Class S4-low and Class S5-very Low. The subclasses are indicated by the letters corresponding to the main limiting soil criteria.

Crop yield prediction

The crop yield prediction module (named Albero) was based on the use of statistical modelling to formulate and calibrate multiple regression equations to predict yields of wheat, corn (maize) and cotton crops. These agroecosystem models were formulated, calibrated and validated over a particular range of management practices, climate, soils and time scales. A high level of management, the general characteristics of a Mediterranean climate, the best agricultural soils and the estimated average yields obtained in recent years, are the experimental parameters which define the selected benchmark Sevilla zone.

The following were considered as diagnostic criteria or x variables: useful depth (x1), clay content (x2), depth to hydromorphic features (x3), carbonate content (x4), salinity (x5), sodium saturation (x6), and cation exchange capacity (x7). According to the statistical test, the independent variables and their interactions accounted for a large part of the variation in yield.

Agricultural field vulnerability

The field vulnerability module (named Arenal) is a knowledge-based model that allows one to predict the relative vulnerability of fields to agrochemical compounds, in terms of soil and groundwater contamination. The following field factors are combined:

a) land factors: precipitation, physiography, water table depth, soil texture, salinity, pH and CEC;
b) management factors: farming system, artificial drainage, water extraction.

Expert knowledge was captured into the ALES system shell (Cornell University, USA), through computer-based decision trees. The mobility of agricultural pollutants (fertilisers and pesticides) by soil infiltration into groundwater was especially taken into consideration. Four field vulnerability classes: S1-none, S2-slight, S3-moderate, S4-severe, were chosen and defined. This expert system can be used to estimate the environmental impact of agricultural activities, with reference to chemical degradation of soil and water resources.

Dataset and toolkit

The dataset module within MicroLEIS includes the major Andalucia datasets used to develop the MicroLEIS system, and makes application of the other evaluation modules within the system easier. The datasets comprise several standard data files from 62 benchmark sites of the Andalucia region of monthly climate data, of landscape and soil morphological and analytical data, and of crop and management data for specific land use systems. The toolkit includes a group of simple tools to estimate soil water balance, to assess erosion and agrochemical transport, along with several pedotransfer functions. Bioclimatic classification uses the method of Thornthwaite, rainfall erosivity estimation by Fournier index and precipitation leaching degree by the Arkley method. Soil texture classes according to several

systems of classification, and their relation to soil physical and chemical properties, are included as qualitative pedotransfer functions.

The computing environment

MicroLEIS was designed and constructed to be applied as a sequential and user-friendly set of tools. Input data are entered from the computer keyboard for each soil, land or field unit to be evaluated, following a menu system and explanatory screen mode. The executable files, when called from the 'Main Menu', will apply the corresponding evaluation modules. Several documentation files give ample information on MicroLEIS by means of an 'Electronic Manual'. System utilities such as: 'Dataset and Toolkit' chapters derive and prepare input data; an 'Evaluation Results' system allows the user to view, edit, print, copy and delete output data files; and 'Presentation Language' section to change from the Spanish to English languages.

The software is a compressed package of compiled BASIC programmes, which runs on IBM PC, XT, AT, or compatible machines with MS-DOS 2.0 or later operating system; 640Kb RAM memory; video, VGA, EGA or CGA cards; floppy drive: 3.5" (1.44Mb or 720Kb) or 5.25" (1.2Mb); and the printer assigned to port LPT1. MicroLEIS 3.2 requires 2.8Mb of hard disk space; and the software is distributed on 5.25" or 3.5" floppy disks.

Materials needed to use MicroLEIS

Although the dataset and toolkit module can make the application of MicroLEIS easier, to use this system effectively, the following information will be needed:

a) the relevant soil survey report, in order to identify the soil types;
b) tabular climate data statistics on a monthly basis from the relevant meteorological stations;
c) the last report on labour operations that identify the farming system of the field types.