Chapter IX

Land Evaluation — An Artificial Intelligence Approach

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INTRODUCTION

A major environmental concern of today's scientists is the inefficient exploitation of natural resources. The land is the ultimate source of wealth and the foundation on which civilization is constructed. Inappropriate land use, leads to destruction of the land resource, poverty and other social problems, and even to the destruction of civilization. To avoid such phenomena, land evaluation is employed, for rational land use planning and appropriate and sustainable use of natural and human resources (Rossiter, 1994).

The management of land use is an interdisciplinary activity that relies on large amounts of information from different sources. Land evaluators need to collect information from soil surveyors, climatologists and census takers on land resource. They also need the expert knowledge of soil scientists, agronomists and economists on land use. In addition, land evaluators must select and apply the most appropriate analytical methods to evaluate land qualities and to combine these into overall physical and/or economic suitability. This evaluation is then calibrated against expert judgement and related experience. Finally they must present the results of the evaluation with reports and maps. This output has to be dynamic, considering the continuous refinement of the whole land evaluation process.

The above characteristics of land evaluation denote that the management of such a process definitely requires the support of computer systems, especially expert systems, remote sensing and image processing systems, and geographical information systems (GIS). Such systems exist, but they are usually stand-alone units, hence human intervention (land evaluators) for the flow of information from one system towards the other is indispensable. Therefore, integrated systems are highly desirable.

The latest research and development trends in this area progressively encompass Artificial Intelligence (AI) techniques to a greater extent, in order to achieve an

optimal performance in the analysis of the vast geographical data. Expert systems were included early on, in an effort to model the domain knowledge of land evaluation from experts. Now, such systems introduce fuzzy logic to cope with uncertainty within the data sources and the inference procedure. Machine learning techniques are also included to model the land evaluation procedures when expert knowledge is insufficient or even absent. In general, there exists an amount of both symbolic and non-symbolic AI techniques, which scientists are keen on combining and integrating with traditional land information systems.

This chapter is structured as follows. An overview of three of the most used AI techniques in land evaluation problems is given. Following that, the next section introduces ISLE (Tsoumakas and Vlahavas, 1999), an Intelligent System for Land Evaluation that is designed as a framework for the integration of AI techniques with a geographical information system. The final section discusses conclusions and future trends in this field.

ARTIFICIAL INTELLIGENCE APPROACHES IN LAND EVALUATION

Expert Systems

In land evaluation, the most widely applied symbolic approach is that of expert systems. Expert systems were developed as an effective way to make use of both theoretical research results and empirical knowledge of soil scientists, agronomists and economists. Domain knowledge is usually encoded in if - then rules. The rules' premises involve measurements of soil and economic factors, and the conclusions involve heuristic classification knowledge of experts.

Rules of the knowledge base in expert systems for land evaluation, are usually organised into groups, providing the means for hierarchical decomposition of the problem. Knowledge about the land characteristics is encoded in groups at the lowest level with individual groups containing rules about characteristics with similar semantics. At an intermediate level, rules for the manipulation and combination of the output that lower level rule firings caused are again encoded into groups of similar semantics. The number of intermediate levels depends on the complexity of the knowledge base. At the top level, there is a final group of rules that actually provide the land classification. Rule grouping offers a way to control the execution of rules in stages, similar to the stages that an expert has to go through when evaluating land. It also adds to the modularity of the knowledge base and consequently to the maintainability and extensibility of the system.

Another essential property of expert systems for land evaluation is the capability for database connection. Land evaluation is a very data intensive procedure. The traditional way for data retrieval by the expert system is a user query. This is time-consuming and can only be applied in small-scale land evaluation tasks. With the advent of geographical information systems, vast amounts of data are available in geographical databases.

One of the most important expert systems that pioneered in the field of land evaluation is the ALES system (Rossiter 1989). ALES is an automated land