



**UNIVERSITI PUTRA MALAYSIA**

**EROSION EXPERT SYSTEM  
FOR  
ENVIRONMENTAL IMPACT ASSESSMENT**

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EROSION EXPERT SYSTEM  
FOR  
ENVIRONMENTAL IMPACT ASSESSMENT

By

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Thesis Submitted in Fulfillment of the Requirement for  
the Degree of Master of Science in the  
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DEDICATED TO:

MY PARENT,

BROTHERS, SISTERS

& ALL MY FRIENDS.

A SWEET LIFE IS A SHARED  
EXPERIENCE



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## LIST OF ABBREVIATIONS

AI	Artificial Intelligence
DLL	Dynamic Link Library
DOE	Department of Environment
EES	Erosion Expert System
ES	Expert System
EIA	Environmental Impact Assessment
GUI	Graphic User Interface
KB	Knowledge Base
UIS	User Interface System
VB	Visual Basic



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**July 1998**

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Soil Erosion is one of the most important natural resources management problems in the world. It is a primary source of sediment that pollutes streams and fills reservoirs. Development especially in hilly terrain will significantly increase this process and cause adverse impact to the local and regional environment. The main purpose of the Erosion Expert System (EES) being developed was to help EIA consultants in preparing the Erosion part of EIA reports besides providing relevant information on erosion. Computer programs developed can help in information retrieval and decision support when dealing with erosion control. The rule-bases of the system was developed using CLIPS version 6.04, an Expert System Shell which was designed by NASA (National Aeronautics and Space Administration). The Graphic User Interface (GUI) for the system was designed by using Visual Basic 5.



Results show that Knowledge-based system would be useful especially if the domain knowledge is systematic. The advantage of Knowledge-based system is that it leads to a greater degree of unification in preparing EIA reports but it should be used only as an alternative source of knowledge since human specialist would be a preferred approach in environmental planning.



Abstrak thesis yang dikemukakan kepada Senat Universiti Putra Malaysia bagi memenuhi keperluan Ijazah Master Sains

## **SYSTEM PAKAR BAGI HAKISAN UNTUK EIA**

Oleh

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Hakisan tanah merupakan salah satu masalah pengurusan sumber semulajadi yang penting di dunia. Ia merupakan punca utama pencemaran sungai dan pencetakan empangan. Pembangunan terutama di kawasan bukit akan menambahkan kesan hakisan dan mendatangkan impak negatif terhadap alam sekitar. Tujuan terutama sistem pakar hakisan ini dibangunkan adalah untuk membantu jururunding EIA menyediakan topik hakisan dalam laporan EIA dan juga menyediakan informasi yang berkaitan. Program komputer ini dapat membantu membuat keputusan dan pengekrasian informasi. "Rule-bases" sistem ini ditulis menggunakan CLIPS yang direka oleh NASA (National Aeronautics and Space Administration). GUI sistem ini direka menggunakan Visual Basic 5. Keputusan menunjukkan sistem yang berdasarkan pengetahuan berguna terutama jika pengetahuan tersebut adalah sistematik. Kelebihan sistem tersebut ialah ia dapat menyelaraskan penyediaan laporan EIA.



Namun demikian ia harus digunakan sebagai alternatif dan penggunaan pakar manusia patut diberi keutamaan dalam perancangan alam sekitar

## CHAPTER I

### INTRODUCTION

#### **Environmental Impact Assessment**

The Environmental Impact Assessment (EIA) in Malaysia has been developed primarily as an aid to the environmental planning of new development projects or the expansion of existing development projects (DOE, 1995). Any person intend to carry out any prescribed activity were to submit a report on the impact on the environment to the Director General, Department of Environment for approval under the amendment of the Environmental Quality Act, 1974.

EIA has been acknowledged as a useful tool, which incorporates environmental factor in making decision regarding new development. It is a study to identify, predict, evaluate and communicate information about the impacts on the environment of a proposed project and detail out the mitigating measures prior to project approval and implementation. The aim of EIA in Malaysia is to access the overall impact on the environment of development projects proposed by the public and private sectors. (DOE, 1995).



EIA is essentially a preventive process. It seeks to avoid costly mistakes in project planning and development; mistakes which can be costly either because of environmental or economic losses that result from modification that might be required subsequently to make the project environmentally acceptable to the Government and to the community. Environmental Impact Assessment, Pollution Control and Resource Planning are together a total approach to environmental management. (DOE, 1995).

### **Soil Erosion**

The menace of soil erosion in Malaysia has been recognised for a long time (Soper, 1938; Fremor, 1939; Hartley, 1949 and Maene and Wan Sulaiman, 1980). Climates with heavy rainfall and a large proportion of the rainfall which falls in storms of high intensity has caused severe and widespread erosion throughout the country (Jamal T., Wan Sulaiman and Mokhtaruddin, 1985). Erosion from bare earth generates siltation, thus reducing channel capacity and causing floods to occur (Schwab et al., 1993). Such disturbances also create chemical changes within the soil composition. Smaller cases of soil erosion may be no more than nuisance, but they can cause money in terms of the damage they do or through the remedial works they require. Although soil loss under rain forest is relatively low it increases rapidly when land is cleared. As pressure on land increases in Malaysia as a result of rapid



development, more areas of rain forests are being cleared. These activities have aggravated the problem of erosion.

Soil erosion is one of the important components that are prepared in most of the EIA reports. So far, the procedures of preparing the reports have been done manually without the usage of the computer technology. Thus, an idea of developing an expert system which could assist the project initiators, EIA consultants or other relevant parties in the preparation of the erosion part of EIA reports has been suggested. This is to save time on environmental data collection that are necessary during environmental impact assessment in order to determine the extent of an environmental effect or predicted most likely impact. Users can use the Expert System which also act as an environmental database for retrieval of related information instead of seeking from related agencies, universities, research institutions and other established sources before embarking on field data collection programmes.

The usefulness of an Expert System or knowledge-based system in environmental assessment depends on whether the task it is reviewing is systematic. Some parts of environmental assessment such as predictions are well suited to the use of knowledge-based system (Lyna, et al., 1993) because the knowledge are highly structured.

## **Expert System**

Rule based Expert System has been recognised as a useful approach in organising relevant heuristic knowledge and analytic information for erosion. For example Ross (1993) created a program to simplify the process of assessing the land parcels in logging operation on steep land. The rule base of the expert system was developed by interviewing field experts. FU (1994) created The Soil Erosion Expert System (SEES). This Expert system can be used to store, uptake, search, analyse, process and display data and images and to map automatically. It is also used to predict soil erosion. Gregori et al., (1993) analysed the potential use of an expert system to evaluate the impact of silvicultural practices. The model defines erosion susceptibility by analysing 56 parameters in six categories (climate, soil, topography, active morphogenic processes, human disturbances and vegetation cover). The system is also suitable for forest management planning as well as silviculture.

## **Statement of the Problem**

EIA usually deals with rather complex problems that touch upon many disciplines and rarely will an individual or small groups of individuals have all the necessary expertise. The Expert System component of an EIA system helps to fill this gap and at the same time take over the role of a tutor (Fedra, 1993).

EIA generally requires a multi-disciplinary team of experts. Thus a study may require not only engineers but also specialists in the biological and chemical sciences besides personnel in social, medicine and economic fields. In addition, there is a need of that expertise to be within the agency which is responsible for managing EIA to review and evaluate the report generated. Finding the manpower with necessary expertise for the above tasks would be a major problem.

### **Objectives**

Recognising the problem of gathering relevant data in preparing EIA reports is time consuming and causes considerable expense beside introducing unnecessary delays to the projects implementation, Expert System is suggested to make necessary information available in a much shorter time. The main objective of this project was to develop an expert system, which will assist project initiators in this following area:

- To make decision in the requirements of EIA for a particular project based on Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987
- To indicate the major potential impacts of a particular project which should be considered during report writing of EIA
- To provide mitigation measures of the particular project that should be considered during report writing of EIA.

- To provide basic information on soil erosion in Malaysia
- To assist EIA expert to prepare the erosion part in EIA reports
- To provide a source of specialised knowledge in a way that is effective and economical

The expert system developed will be based on the procedures and requirements needed in Malaysia. The benefit that could be realised from such a system is that it provides a standard and consistency in the preparation of EIA report on erosion. Besides that, it also allows users at any level to access and use the Expert System to assist in preparing the report.

### **The Expected Result**

The expected outcome of this research is a prototype of Erosion Expert System (EES). It can be used by the expert to retrieve necessary information related to soil erosion in EIA reports and by project proponents to prepare their EIA reports in a shorter time. Storing existing environment, expected potential impacts and mitigation measures description in the system database, lead to save time needed to collect environmental data. That will also solve the problem of insufficient EIA experts. This system is expected to have a friendly Graphic User Interface (GUI) as well as providing satisfying soil erosion information needed for EIA report.

## **CHAPTER II**

### **LITERATURE REVIEW**

#### **Introduction**

Environmental planning and management problems are generally well suited to solve using expert systems technology because: 1) The problem domain is generally well defined even though the physical system might be poorly understood. 2) Conventional wisdom regarding alternative solutions frequently resides with those individuals having a great deal of special experience and expertise within fairly narrow areas even though (or perhaps because) this knowledge is necessary multidisciplinary (Wright, 1993). 3) It is difficult to gather expert in the same place at the same time or to visit each individual expert.

The discussion in this chapter includes expert system in general, a summary of past research, number of expert systems which are used in environmental impact assessment study and applications of expert system in soil erosion studies.



## Expert System

Expert system is a program that uses inference technique, which involve formal reasoning normally performed by a human expert to solve problems in a specific area of knowledge. Expert system can advise, diagnose, analyse and categorise using previously defined knowledge base. Knowledge base is a collection of rules and facts.

Expert System is a branch of artificial intelligence (AI) that uses human knowledge and expertise to solve problems ordinarily requiring human intelligence (Hayes, 1983). It used heuristic rather than algorithms to solve problem in various fields of expertise (Jackson, 1986; Waterman 1986).

It is designed to replicate human expertise over a general set of problem domain. Expert systems may be thought of as logic-based rule processing software, where the rules embody the expertise in question. Early applications included medical diagnoses, storage of hazardous chemical, and military deployment.

Early attempts by computer scientists to develop computer models of cognitive behaviour, by applying traditional procedural programming, did not result in recognisably 'intelligent' behaviour (McCorduck, 1979). After much controversy, the AI community concluded that human intelligence results not from applying clever

algorithms to problems but from rapid access to a large amount of information gained from experience (Winograd, 1975). AI research are still unable to replicate the behaviour of humans in solving every day problems because of the vast amount of information needed in making even a simple decision. But there is greater success in modelling expert behaviour because of smaller amount of highly structured information that constitutes expertise in a specialist problem domain.

Researchers in the field of Expert System used the term 'Knowledge Engineering' to describe the discipline of developing Expert System. According to Waterman et al. (1983), Knowledge Engineering started by extracting expert's knowledge, which is then organised and implemented in a computer system.

### **The Use of Expert System in Environmental Planning**

Expert System has been widely used in many areas or fields of knowledge such as medicine, chemistry, electronic, geology, industry, management and so on. Many systems had been developed in various fields of studies.

Schibuola and Byer (1991) described the use of knowledge-based expert systems applied to the review of environmental impact assessments (EIA). They provided a solid argument that the quality of environmental impact assessment and public participation can be improved if the public could effectively review the EIA

document. The public group will benefit from having available specific knowledge needed to perform good reviews. A knowledge-based system (KBS) can potentially disseminate this knowledge in an inexpensive and readily usable form. They evaluated the usefulness of the KBS approach by developing a research prototype capable of critiquing a central component of EIA-the evaluation of alternatives. Case studies demonstrated the system's effectiveness and the quality of its interaction with non-experts. Schibuola and Byer provide a comparison of this approach with other, more traditional methodologies.

An Expert System for the Management of the water quality in the Latrobe River was developed by Elliott and Ciesielski (1993). They described the design and development of an expert system for managing river water quality. The state Electricity Commission of Victoria (Australia) draws large volumes of water from the Latrobe river for use in its electricity generation activities. The use of this water can result in large variations in river flow and water temperature and subsequent environmental damage. The Commission is concerned with keeping its use of water within the constraints imposed by the environmental Protection Authority while at the same time operating its generation plants to maximum efficiency. The flow of water can be controlled by valves in a number of water storage and a charge engineer is responsible for setting the valve openings to ensure that the river flows and water temperatures at a number of monitoring points are within limits. The water flow pattern are highly complex, involving a number of weirs, cooling tower



and pumps and not all necessary information is available. Decisions are made using a combination of available data and heuristic rules gleaned from previous experience with the system. The authors described a rule-based expert system designed to capture the expertise needed to operate the valves in a way that ensures river flows and temperatures remain within limits. The prototype system, which was developed using the popular VP-EXPERT tool.

Fang et al. (1990) in *Multi-Domain Expert Systems for Hazardous Waste Site Investigation* discuss the problem of growing concern in the U.S. and around the world regarding the comprehensive evaluation of sites have been or will be used for the storage and disposal of hazardous materials. They described the development of a multi-domain knowledge-based expert system to be used to aid decision-makers in addressing these types of complex problems. After outlining the general approach to site analysis and investigation, the authors present a framework within which to conduct the assessment of technical, social, and economic factors, portraying the task as one that can benefit from the use of expert systems technology. A system for supporting this methodology has been developed using the GEOTOX shell tool. The details of system design and implementation, knowledge representation, and use were presented.

Chen and Ronald (1993) in *NOISEXPT: An Expert System for Noise Control in Very Fast Train Design* describe the NOISEXPT knowledge-based system which

