UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF AN EXPERT SYSTEM FOR ENVIRONMENTAL MANAGEMENT PLANNING: SOIL AND WATER CONSERVATION

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This thesis is dedicated to the author's beloved mother, Thongjua Pattatesang and the stepfather, Somchai Pattatesang, who is always the gentleman in the author's mind

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Chairman: **Associate Professor Mohamed Daud, Ph.D., P.Eng., MBA**

Faculty: **Engineering**

A computer-based expert system, EMP-Ex, has been developed for environmental management planning with regard to soil and water conservation, particularly during earthwork activities of development projects. It is a rule based expert system programmed in wxCLIPS 1.62. The EMP-Ex is able to predict soil erosion rate and peak runoff caused by development activities and then recommends suitable strategies for conserving soil and water resources, monitoring the effectiveness of mitigation measures and water quality. The system provides users a checklist of required items and suggestions for steps to be taken in the preparation of Environmental Management Plan (EMP) including planning for emergencies and in the production of an EMP report. The system's knowledge base comprises descriptive and prescriptive knowledge elicited from domain experts and additional supporting information acquired from literature. The domain knowledge was incorporated into the system in the form of production rules that can be updated and referred to through the system. EMP-Ex has been verified and validated to evaluate system capabilities by wxCLIPS facilities, face validation, Turing test, and field study. The results show that EMP-Ex is able to function as good as human experts

with a ninety-five percent of confidence level. Through interfacing with other external programmes (e.g. AutoCAD, IDRISI, Microsoft Office, Netscape Navigator etc.), the system extends its capability in sharing and storing raw knowledge and external databases for further reference or updating and provides users the convenience in using additional facilities of the external programmes interfaced. By automating EMP processes, not only can EMP-Ex help EMP planners to improve the quality and the quantity of work, but it can also assist the authorised agencies such as the Department of Environment (DOE) in auditing and revising the plans, especially in the situation of insufficient human experts.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PEMBANGUNAN SISTEM PAKAR UNTUK PERANCANGAN DAN PENGURUSAN ALAM SEKITAR: PEMULIHARAAN SUMBER TANAH DAN AIR

Oleh

SUTTIPONG PRUANGKA

Disember 2000

Pengerusi: **Profesor Madya Mohamed Daud, Ph.D., P.Eng., MBA**

Fakulti: **Kejuruteraan**

Sistem pakar EMP telah dibangunkan melalui program wxCLIPS 1.62 untuk tujuan perancangan dan pengurusan alam sekitar. EMP-Ex berupaya meramalkan tahap hakisan tanah dan aliran air puncak yang akan berlaku akibat aktiviti pembangunan. Selain ramalan, sistem ini juga menawarkan cadangan seperti langkah-langkah pencegahan, environmental monitoring, pemuliharaan sumber tanah dan air untuk mengelakkan atau merendahkan kesan-kesan buruk. Sistem ini juga memberi senarai penyemakan dan cadangan kepada pengguna di dalam langkah-langkah penyediaan Environmental Management Plan (EMP), termasuklah perancangan untuk kejadian kecemasan. Di samping itu, satu laporan EMP akan dihasilkan untuk pengguna. Dasar pengetahuan sistem dibangunkan berdasarkan maklumat yang diperolehi daripada pakar-pakar di dalam bidang berkaitan serta bahan bahan rujukan yang terdapat. Dasar pengetahuan tersebut bukan sahaja menawarkan perujukan maklumat malahan membenarkan pembahuruan maklumat dilakukan demi bersesuai dengan keadaan semasa. Kebolehan EMP-Ex telah diuji dan disahkan melalui kemudahan wxCLIPS, face validation, turing test dan kajian di tempat sebenar. Pengujian telah memberi keputusan bahawa kebolehan EMP-Ex

adalah setanding dengan pakar-pakar manusia dan mempunyai tahap kepercayaan sebanyak sembilan puluh lima peratus. Pelingkaran kepada perisian-perisian seperti AutoCAD, IDRISI, Microsoft Office, Netscape Navigator dan sebagainya telah melanjutkan kebolehan sistem ini serta memberi kemudahan kepada pengguna. Kesimpulanya, EMP-Ex dapat membantu perancang EMP atau pihak berkaitan seperti Jabatan Alam Sekitar (DOE) dalam meninggikan kualiti perancangan dan pembuatan keputusan, terutama pada keadaan kehausan tenaga pakar ini.

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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
ANSI	American National Standards Institute
CLIPS	C Language Integrated Production System
COOL	CLIPS Object Oriented Language
DBMS	Data Base Management System
DID	Department of Drainage and Irrigation
DOE	Department of Environment
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EMP-Ex	Environmental Management Plan Expert System
EMS	Environmental Management System
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organisation
GIS	Geographic Information System
GUI	Graphical User Interface
MARDI	Malaysia Agricultural Research Development Institute
NASA	National Aeronautics and Space Administration
RAM	Random Access Memory
VGA	Video Graphic Accelerator

CHAPTER I

INTRODUCTION

It is now generally accepted that economic development strategies must be compatible with environmental goals. This requires the incorporation of environmental dimensions into the process of development. It is important to make choices and decisions that will eventually promote sound development by understanding the environment functions. During the construction phase of development projects, the removals of vegetation cover together with earthwork activities reduce the stability and bonding of soil. Without the protection and binding properties of vegetation, there will be serious problems of soil erosion and water resource deterioration.

In response to this threat, it is recognised that environmental consideration should be fully taken into account at the earliest project planning stage. Thus, Environmental Impact Assessment (EIA) which involves the integration of environmental factors into development planning is now recognised as a tool in environmental management (FAO, 1995). An objective of EIA is to develop Environmental Management Plan (EMP) for ensuring that the proposed development activities are undertaken with due consideration to the conservation of the ecosystem and sustainable development.

In environmental management planning for development projects, soil and water conservation, erosion and sediment control, and environmental monitoring programme are considered very important parts of EMP. With the recently

introduced ISO 14000 series on Environmental Management System (EMS), there are provisions for the design of an EMP that includes provisions for the management of soil and water during site clearing and earthworks (DOE, 1996). However in Malaysia, the EMP has just been developed as a part of environmental assessment in late 1995; therefore, the concept of environmental management planning is relatively new in the Malaysian context and information is very sparse.

Statement of the Problem

Some of the main problems in applying EMP procedure in Malaysia are:

1. It is costly to engage the required team of specialists competent enough to examine in detail the diverse topics encountered in an EMP.

2. Failure to propose environmental monitoring which is a part of the EMP or failure to propose Emergency Response Plan (ERP).

3. The existing EMPs attached in EIA reports are not consistent. There are various formats and practical details are not enough, especially in soil and water conservation that is very important in environmental management planning.

Furthermore, it cannot be denied that the period required by project proponents, environmental consultants, to prepare high quality plans and authorised agencies to review the plans can be shortened. Moreover, budget can be saved if

there is an appropriate technology for helping these working groups (We Lin and Noor, 1995). Therefore, the idea of developing an expert system computer programme, which could assist in solving these problems, has been suggested. Furthermore, the expert system is efficient and fast in continuous updating and extracting large databases to be applied appropriately.

Research Objectives

The specific objectives of this study were:

1. To check the existing information of EMP and related information from the Department of Environment;

2. To extract and encode knowledge from domain experts together with knowledge from established literature on main problems related to environmental management planning in soil and water conservation for developing rule-bases of an expert system;

3. To provide practical knowledge bases regarding problems of soil and water conservation during earthwork activities of development projects; and

4. To develop a comprehensive expert system that can be used as a device for preparing environmental management plan with regard to soil and water conservation.

Scope and Limitations

Only the design and operational aspects for soil and water conservation in environmental management plan (EMP) were considered in this study. The other components of the EMP, such as planning for air and noise quality, forestry and wildlife, and other social factors were not taken into account.

Expected Outcome of the Study

The expected outcome of this study is an expert system prototype called "**E**nvironmental **M**anagement **P**lan **Ex**pert System (EMP-Ex)" that will be useful to prepare high quality EMP reports, especially in the situation of insufficient human experts. The expert system developed will also assist authorised agencies such as the Department of Environment (DOE) in auditing and revising the plans. Furthermore, it has significant potentials for use in environmental training and education, particularly when there is shortage of expertise as in the field of environmental assessment.

CHAPTER II

LITERATURE REVIEW

Economic, social and environmental change is inherent to development. Whilst development aims to bring about positive changes, it can lead to conflicts. In the past, the promotion of economic growth as the motor of increased well-being was the main development thrust with little sensitivity to adverse social or environmental impacts. The need to avoid adverse impacts and to ensure long-term benefits led to the concept of sustainability. This has become accepted as an essential feature of development if the aim of increased well-being and greater equity in fulfilling basic needs is to be met for this and future generations. In order to predict environmental impacts of any development activity and to provide an opportunity to mitigate against negative impacts and enhance positive impacts, the environmental impact assessment (EIA) procedure was developed in 1970s.

Environmental Impact Assessment

Environmental impact assessment (EIA) can be defined as the process that identifies, predicts, evaluates, and communicates information concerning the adverse and beneficial impacts of proposed projects, plans, programmes, or legislative actions relative to the physical, chemical, biological, cultural, and socio-economic components of the total environment (DOE, 1995b; Canter, 1996). The EIA also specifies any mitigation measures that are required to alleviate significant environmental impacts, prior to project approval and implementation (FAO, 1995). It is important to understand where EIA fits into the overall scheme of environmental management. Pollution control is essentially a curative process