



UNIVERSITI PUTRA MALAYSIA

**TERRESTRIAL VEGETATION MANAGEMENT
EXPERT SYSTEM (ES) PROTOTYPE FOR
ENVIRONMENTAL IMPACT ASSESSMENT (EIA)**

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FK 1998 21



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EXPERT SYSTEM (ES) PROTOTYPE FOR
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By

VIKNESWARAN NAIR A/L SEHKARAN

**Thesis Submitted in Fulfilment of the Requirements for the
Degree of Masters Science in the
Faculty of Engineering
University Putra Malaysia**

May 1998



Specially dedicated to

Beloved mum and dad,

Sister Shoba and brother Ramesh,

Thank you for your love and support.



ACKNOWLEDGEMENTS

I wish to express my sincere thanks and gratitude to my supervisor Ir. Dr. Mohamed Daud for his invaluable advice, guidance, ideas, encouragement and patience throughout the course of this study. Thanks are also due to my supervisory committee, Dr. Nathan Ganapathi and Dr. Abdul Rahman Ramli for their intelligent supervision, helpful suggestion and constructive criticism.

Special thanks also go to my family, close friends, collegians from KTP, course mates and my roommate, Kulanthayan for their help in one way or the other in preparing this research. Their moral support kept me sail through the development of the work.

The study has been a great experience and has given me valuable insight into the field of information technology in environment. I submit in humility and gratitude to the Supreme Power for all his blessings and generous help from sources that were beyond our expectation.



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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
ANSI	American National Standards Institute
ART	Automated Reasoning Tool
CLIPS	C Language Integrated Production System
COOL	CLIPS Object Oriented Language
DOE	Department of Environment
DYNACLIPS	Dynamic CLIPS Utilities
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EQO	Environmental Quality Ordinance
ES	Expert System
FRIM	Forest Research Institute of Malaysia
GIS	Geographical Information System
GUI	Graphical User Interface
IBM PC	International Business Machine Personal Computers
NASA	National Aeronautics and Space Administration
OPS5	Operating System 5
RAM	Random Access Memory
TOR	Terms of Requirement
VGA	Video Graphics Monitor
WWF	World Wildlife Fund



Abstract of thesis submitted to the Senate of University Putra Malaysia
in fulfilment of the requirement for the degree of Master of Science.

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The tropical rainforest of Malaysia holds one of the richest flora in the world. The favourable climate has produced flora of amazing richness and variety. Terrestrial vegetation of tropical rainforests is an important feature of the environment. Plants play a major role in the environment. Conservation of a particular environment depends fundamentally on the maintenance of existing plants and their communities and hierarchies. Therefore, the application of a computer technology in the form of an expert system (ES) will be able to help in the analysis and management of the EIA information. The ES is named VEGEVIC. A rule-based system is developed to guide the user in producing an EIA report. Knowledge for this system is elicited from the domain expert through interviews, existing literature and EIA reports between 1995 and 1997. Application of the system will lead to greater consistency in producing a standard approach when preparing an EIA report.



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

**PROTOTAIP SISTEM PAKAR(ES) PENGURUSAN TUMBUHAN
DARAT BAGI PENILAIAN KESAN ALAM SEKITAR(EIA)**

Oleh

VIKNESWARAN NAIR A/L SEHKARAN

Mei 1998

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Hutan hujan tropika di Malaysia mempunyai flora yang terbanyak di dunia. Keadaan cuaca yang sesuai telah menggalakkan flora yang kaya dengan kepelbagaian yang menakjubkan. Tumbuhan darat di hutan hujan tropika merupakan suatu daripada ciri penting persekitaran. Tumbuh-tumbuhan memainkan peranan utama dalam alam sekitar. Pada dasarnya, pemuliharaan persekitaran tertentu bergantung kepada pengekalan tumbuh-tumbuhan yang sedia ada, komuniti dan tertib susunan mereka. Maka, penggunaan teknologi berkomputer dalam bentuk sistem pakar akan membantu dalam analisis dan pengurusan maklumat EIA. Sistem pakar ini dikenali sebagai VEGEVIC. Sistem yang berasaskan peraturan ini akan menjadi panduan pengguna dalam menghasilkan laporan EIA. Pengetahuan serta kepintaran bagi sistem ini diperolehi daripada pakar utama dalam bidang ini melalui temuduga, serta daripada rujukan yang sedia ada dan laporan EIA antara tahun 1995 hingga



1997 Penggunaan sistem ini akan menerajui penghasilan pendekatan seragam yang lebih konsisten dalam penyediaan laporan EIA

CHAPTER I

INTRODUCTION

Prelude

Environmental Impact Assessment (EIA) is acknowledged as a useful tool which incorporates factors in making a decision prior to any development project. It is a study to identify, predict, evaluate and communicate information of the impact on the environment of a proposed project. Mitigation measures prior to project approval and implementation are detailed out.

62% or 20.4 million hectares of Malaysia is still under evergreen tree cover (Khairuddin, 1992). The nation is undertaking careful management, conservation, rehabilitation and research to ensure that its forests and their rich biodiversity are maintained in perpetuity.

Malaysia is a highly developed country in South-east Asia and in the developing world as a whole (Aiken and Moss, 1976). It provides some excellent examples of rapidly changing man-environment relationship of a type that is soon to be expected in many other Third-World countries. Land development and forest clearance have resulted in the opening up of vast areas to



new rural settlements, a process paralleled by rapid urbanisation. Plants are major factors conditioning an environment, and conservation of a particular environment depends fundamentally on the maintenance of existing plants and their communities and hierarchies (Thompson, 1975). Interference in the balance of any of these produces radical changes that lead to progressive deviations from the original situation. These deviation in turn may alter irrevocably the conditions for plant growth and the existing flora.

The current economic growth, with high rates of population increase and rapidly expanding urban numbers and unabated pressure on forest and natural vegetation lead to severe imbalance between man and his natural environment. EIA is a must for most of the development projects undertaken in Malaysia. It is essentially a planning tool for preventing environmental degradation due to human interference. It seeks to avoid costly mistakes in project implementation, or because of modification that may be required subsequently in order to make the action environmentally acceptable. A matrix is a two dimensional checklist of environmental components and project activities issued to identify and communicate the potential environmental impacts of a proposed project (Appendix A). The environmental matrix technique is outlined by Fortelli (1990) in the planning of agricultural land use. Terrestrial vegetation is an important matrix of the EIA report.

Problem Statement

Delays in submitting EIA reports are often a cause of delay to project approval and implementation. No standard procedures are followed by consultants in preparing the EIA. There is still not enough specific guidelines or procedures for the project proponent and consultants in preparing EIA reports. Therefore, inconsistent approaches to EIA due to the insufficient environmental experts to evaluate the reports. As mentioned in the Department of Environment's (DOE) Annual Report 1995, the number of EIA reports received since the enforcement of the EIA Order 1987 are increasing. This is illustrated in detail in Appendix B and C. Due to shortage of manpower, the DOE is also having problem in evaluating EIA reports and to carry out a post monitoring of the compliance of the conditions stated in the approval letter.

The usefulness of an EIA study is in its application early in the stage of project planning. EIA studies undertaken late in the project cycle do not assist in project planning. Further, project delays are more often than not due to lateness in undertaking an EIA. As a result, project approval by the relevant authorities are often delayed and the need to make changes to project to make it acceptable aggravates the situation. To avoid delays and to ensure usefulness of an EIA project planning, it is important to identify the levels in a project cycle to which environmental consideration should be incorporated. Adequate time and data are also important to enable the appointed environmental consultants to come up with a report that is accurate enough and reliable.

In general, the two main drawbacks in the current practice of EIA are insufficient environmental expertise and lack of consistent approaches to EIA in satisfying the requirement of national environmental regulatory authorities. In addition, human expertise can be very difficult to transfer, document and at times can be unpredictable. According to Ting (1997), in most situations, expertise are not available on a reliable basis. Experts are expensive, scarce and in high demand. In order to satisfy this standard, knowledge based Expert System (ES) has merged in the field of Artificial Intelligence (AI) with strong potential and capability for reducing training cost, maintaining consistent expert knowledge besides improving productivity and the quality of the task performed (Jackson, 1992).

Research Objectives

The objectives of this research are:

- I. to design, develop, test and implement an ES for EIA to enhance the procedures of environmental assessment activities namely the conservation of terrestrial vegetation for approval and monitoring of the compliance of the approved guidelines.
- II. to create a database in cataloguing, characteristic determination, suitable natural environment and the effect of a project on these terrestrial vegetation.

III. finally to extract the opinions of the expert in contrast with the literature in order to produce a set of rules to enable the ES to be used to make decision.

Scope of Study

The expert system is developed based on the existing legislation on the environment. Where no guidelines are available, recommendations based on the existing EIA reports, literature and expert knowledge are incorporated. This study will emphasise on general terrestrial vegetation management in the Peninsular Malaysia. Guidelines for forest harvesting and agricultural development is incorporated based on the standards set under the provisions of the Sarawak Natural Resources and Environment (Amendment) Ordinance 1993 and the Natural Resources and Environment (Prescribed Activities) Order 1994.

Possible Contribution and Output of the Research

As EIA process involves the collection, analysis, interpretation and review of an extensive amount of information, the use of computer technology in the form of an ES is very vital. An ES named VEGEVIC Version 1.0 is developed and used to aid the EIA consultants, project managers and the DOE to predict the diversity and distribution of the terrestrial vegetation and to

preserve these species. With this ES, the flora aspect of the EIA report can be written. VEGEVIC is abbreviated for Vegetation Expert of Vicky.

CHAPTER II

LITERATURE REVIEW

Environmental Impact Assessment (EIA)

The term *environment* can be interpreted broadly to include physical, social, cultural, economic and aesthetic dimensions which affect individuals and communities and ultimately determine their form, character, relationship and survival (Ray and Wooten, 1980). Examples of such factors are: air and water quality, erosion control, natural hazards, land use planning, site selection and design, subdivision development, conservation of plant and animal life, urban congestion, overcrowding, displacement and relocation resulting from public or private action or natural disaster, noise pollution, urban blight, code violations and building abandonment, urban sprawl, urban growth policy, preservation of cultural resources, urban design and the quality of the constructed environment, and the impact of the environment on people and their activities.

EIA is a process to predict the environmental consequences of a project or decision (Epp *et al.*, 1995). It is a study to identify, predict, evaluate and communicate information about the impact on the environment of a proposed

project. EIA details out the mitigation measures prior to project approval and implementation. Hence, EIA provides an excellent focus for detailed problem solving and analysis. Many EIA techniques could be applied in routine planning efforts without the need for a full assessment of every action (Dunster, 1992). On the whole, the EIA is focused on what should be done in the future rather than rectifying past mistakes (Freebairn and Porter, 1991).

According to Ray and Wooten (1980), the dimensions of the environment can be further elaborated upon and categorised as follows:

1. Physical environment (natural and constructed)

- a) Land and climate
- b) Vegetation, wildlife and natural resources
- c) Surrounding land uses and physical character of areas
- d) Infrastructure/public services
- e) Air pollution levels
- f) Noise levels
- g) Water pollution levels

2. Social Environment

- a) Community facilities and services
- b) Employment centres and commercial facilities servicing area
- c) Character of community

3. Aesthetic Environment

- a) Location of site
- b) Scenic areas and natural landscape
- c) Architectural character

4. Economic environment

- a) Level of employment/unemployment
- b) Level/source of income
- c) Economic base of area

Generally, all environmental impact can be categorised as either primary or secondary impact. This distinction is important for consideration of alternatives and ways to minimise adverse impacts in performing impact assessment or analysis. Primary impacts are those that can be attributed directly to the proposed action. Secondary impacts are indirect or induced changes and typically include the associated investment and changed patterns of social and economic activities likely to be stimulated or induced by the proposed action.

Environmental Impact Assessment in Malaysia

In Malaysia, EIA process is a mandatory legal requirement under Section 34A of the Environmental Quality Act, 1974 for activities prescribed under the Environmental Quality (Prescribed Activities)(Environmental Impact Assessment) Order, 1987 (Appendix D). The aim of an EIA is to ensure that

potential environmental problems are foreseen and addressed at an early stage of project planning and design (DOE, 1995) Information derived from an EIA study are used to design an environmentally sustainable project or decision by avoiding potentially adverse impacts that may affect the environment and the viability of the project or decision Various legislative and regulatory mechanism (Ross and Saunders, 1995) including economic policies (Gills *et al.*, 1992) are developed to prevent or to control the adverse environmental impact.

The Natural Resources and Environment Order 1994 is made under provisions of section 11A(1) of the Natural Resources and Environmental Ordinance which empowers the Natural Resources and Environmental Board to require the submission of a report on activities having an impact on the environment and natural resources namely terrestrial vegetation.

Environmental Guidelines and Standard

In Malaysia, six general steps are to be followed to complete a set of required EIA report (DOE, 1995) They are as follows:

- a) Screening to determine the level of EIA required
- b) Scoping and preparing of Term of References (TOR) for EIA report
- c) The preparation of the report
- d) Review of EIA report
- e) Approval of EIA report with terms and conditions

f) Follow-up and monitoring

Further to this, three major steps are taken in the EIA procedure

- a) Preliminary Assessment
- b) Detailed Assessment
- c) Review

The outline of EIA procedure in Malaysia is shown in Appendix E. There are 19 prescribed activities in the Environmental Quality Ordinance (EQO), 1987. They are those which is related to agriculture, airport, drainage and irrigation, land reclamation, fisheries, forestry, housing, industry, infrastructure, ports, mining, petroleum, power generation and transmission, quarries, railways, transportation, resort and recreational development, waste treatment and disposal and water supply.

Besides Malaysia, EIA is mandatory in many other countries as well. Among the sectors and countries where EIA is emphasised are forestry in Switzerland (Sieber, 1994, Heinemann, 1994), Italy (Corona *et al.*, 1989, Marinelli and Romano, 1990), agriculture in Asia and the Pacific (Asia Productivity Organisation, 1992), Indonesia (Kasryno *et al.*, 1991), mining in India (Ahmad, 1992), golf-courses in Italy (Zingari, 1990); Western Europe (Wheat, 1994; Stubbs, 1995) and Germany (Schulze-Hagen, 1992) and irrigation in India (Ahmad and Singh, 1991)

Terrestrial Vegetation (Flora) Conservation and Ecosystem

Terrestrial vegetation is an important feature of the environment. Most vegetation are indigenous or native to the area in which they are found but some may be alien and troublesome. Retention or removal of natural communities and their replacement with domestic forms have numerous complications that must be considered both ecologically and economically. The impacts affecting the ecosystem must be studied (Di-Giovanantonio and Cupo, 1991; Melick, 1990; Wickramagamage, 1990) of plant and animal populations, and it differs from a natural community designation in that it involves the total nutrient and energy economies of the system as well as the organisms involved. Ecosystems are self-contained and self-maintaining. Natural ecosystems are invariably richer in species and more stable than those artificially developed. The complexity and variability of ecosystems and their recovery capabilities make precise quantitative predictions impossible. The environmental impact of an ecosystem depends on the environmental value of the method of cultivation and the agronomic sensitivity of the area (Di-Giovanantonio and Cupo, 1991). Nevertheless, the repetition of environmental impacts has escalated in recent years, especially in Malaysia, so much so predictions are becoming more reliable.

Projects and activities usually produce adverse biological consequences of two types, direct or indirect impact, and of varying duration, short-term or long-term (Ray and Wooten, 1980). Direct impacts are those that destroy, displace, or in some way adversely affect the vegetation. Whereas indirect

impacts are those that destroy or disrupt habitats and ecosystems upon which a species depends. This is illustrated in Figure 1.

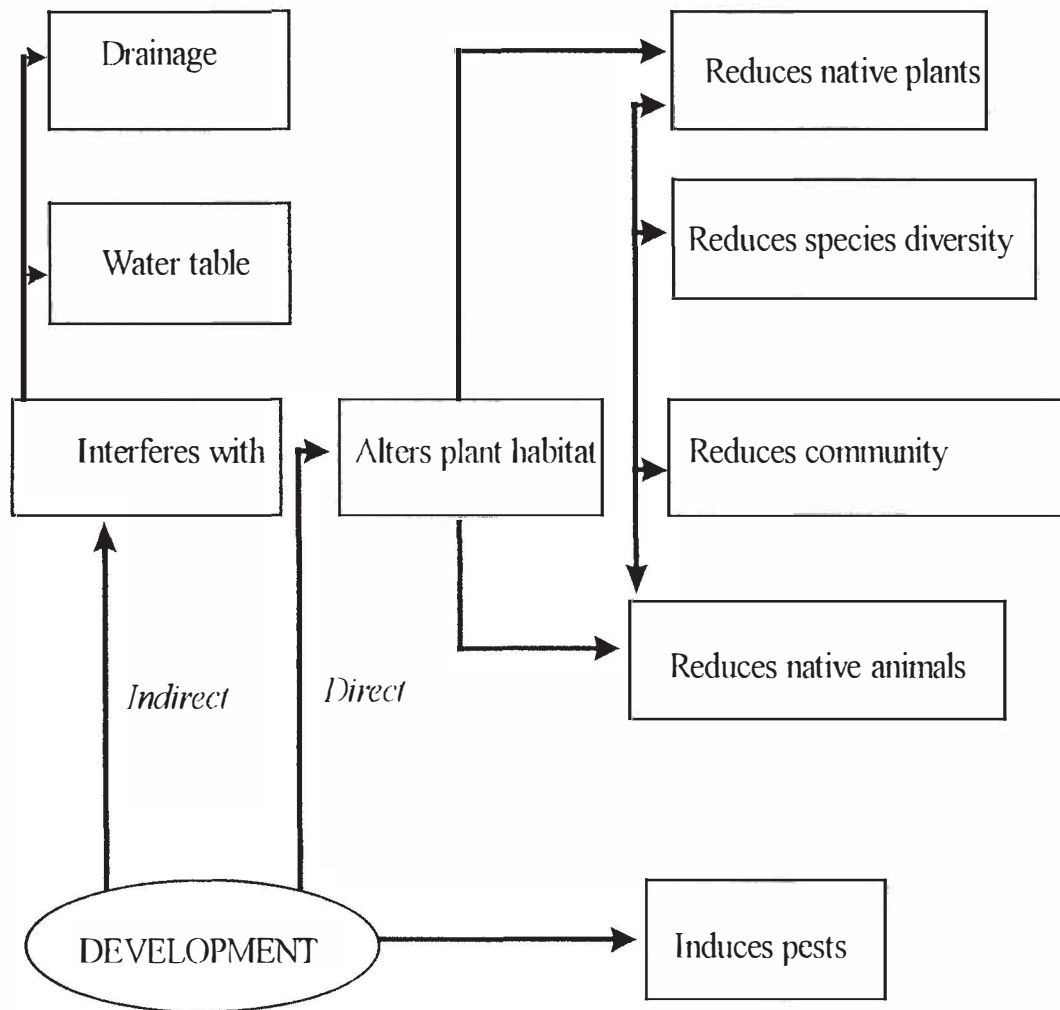


Figure 1: Direct and Indirect Impacts of Development on the Ecosystem.

Alteration or removal of natural vegetation has been the primary cause of habitat destruction in native plants and species extinction. Any proposed project that will alter or remove native vegetation must consider the environmental impacts. The need for sustainable vegetation such as forest development (Heinrich, 1995) is of paramount importance.