UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF AN EXPERT DATABASE SYSTEM FOR ENVIRONMENTAL IMPACT ASSESSMENT (EDEIA)

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DEVELOPMENT OF AN EXPERT DATABASE SYSTEM FOR ENVIRONMENTAL IMPACT ASSESSMENT (EDEIA)

BY

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Dedicated to my respected parents
beloved sisters and brothers

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LIST OF ABREVIATIONS

AI	Artificial Intelligence
DBMS	Data Base Management System
EDS	Expert Database System
EDEIA	Expert Database System for Environmental Impact System
EIA	Environmental Impact System
ES	Expert System

Abstract of thesis submitted to the Senate of
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Development of an Expert Database System for Environmental Impact Assessment

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Expert Database System for Environmental Impact Assessment (EDEIA) was developed using FoxPro and CLIPS. It consists of a database and an expert system prototype. The EDEIA system developed a database system that allows an EIA expert to manage EIA report information and produced a set of rules that enable the ES to be aware of the existing environment component classes. The rules were developed according to the environmental component classification characteristics. The system is based on three assumptions: the environmental components and prescribed activities should be classified, the description of environmental component classes as well as the prescribed activities information must be collected; and finally, the potential impact, mitigation measures and residual impact have to be clearly specified. The main role for EDEIA is to assist EIA experts and companies in producing complete and efficient EIA reports. The system is very useful in supporting EIA expert prediction of expected potential environment impact and best method for mitigation measures. The EDEIA system has friendly graphical user interface, as well as satisfying EIA report requirements.

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Development of an Expert Database System for Environmental Impact Assessment

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'Expert Database System for Environmental Impact Assessment' (EDEIA) adalah lanjutan bagi penggunaan FoxPro dan CLIPS. Ia terdiri daripada pwting satu sistem database dan sistem kepakaran asas. Sistem EDEIA yang memperkemaskini sistem database di mana membenarkan seseorang pakar dalam sistem kepakaran mengurus komponen informasi kajian EIA dan mengeluarkan satu set tatacara yang membolehkan Expert System mengenalpasti kelas komponen environmen yang sediada. Tatacara telah dipermajukan mengikut kelasifikasi komponen petunjuk environmen. Sistem ini didasarkan kepada tiga andaian; Komponen environmen persikataran dan aktiviti yang didedahkan sepatutnya dikelasifikasikan; Kelas pendedahan komponen environmen sepertimana maklumat aktiviti yang didedahkan sepatutnya dikumpulkan; dan akhir sekali, Kemungkinan kesan, pengukuran mitigasi dan kesan residual hendaklah jelas dikelaskan. Peranan utama bagi EIA ialah membantu pakar-pakar EIA and enterpreneur dalam mengeluarkan laporan-laporan EIA yang lengkap dan berkesan. Sistem ini sesungguhnya amat berguna dalam menyokong ramalan pakar EIA terhadap jangkaan environmen serta merupakan kaedah terbaik bagi pengukuran mitigasi. Sistem EDIA merupakan pengguna bersemuka grafik peramah, tambahan pula dapat memuaskan keperluan-keperluan laporan EIA.

CHAPTER I

INTRODUCTION

Environmental Impact Assessment (EIA)

Environmental Impact Assessment (EIA) is a process designed to identify and predict the impact of man's health as a result of a development project and also to interpret and communicate information about that impact (DOE,1995). EIA is generally understood to be an instrument of preventive environmental management. It should provide an adequate information basis for decision making on activities affecting the environment. All environmentally relevant impacts of development should be identified, analysed and evaluated. The purpose of EIA is to ensure that appropriate attention is paid to environmental issues.

Department of Environment (DOE) specifies the objectives of EIA study. These are: first, to examine and select the best from the project options available; there are two types of options to be considered in EIA; these are, major design options, for example choice of process, type of transportation system or waste disposal system, and project site (location) options. The next objective is to identify and incorporate into the project plan an appropriate abatement and mitigating measures; these are measures adopted into the final project plan which either

moderate or forestall a potential environmental impact. They also help to predict significant residual environmental impact, that is, the potential impact remaining after mitigating measures have been adopted into the project plan. The final objective is to determine the predicted significant residual environmental impact and to identify the environmental cost and benefits of the project to the community.

In order to complete an EIA efficiently and to achieve its objectives, the following phases shown in Figure 1 should be taken into consider (Masera and Colombo,1992): The first phase is a description of the project (consider its possible linkage with plans, programmes and the alternative possible technical solutions), and also a description of the environment (i.e. the place where the project will be installed). The second phase is the identification of the environmental effects (with consideration of potential and important effects), and evaluation of the environmental effects (with discussion of the information needed and the methods to be used). The third phase concerns the management and control of the environmental effects (i.e., the mitigation, compensation and monitoring measures that could modify, minimise, etc., the effects). The fourth phase is a presentation of the study (considering how to communicate the result of an EIA). The fifth phase is participation of the public (discussing an EIA study with the public). The last phase involves judgement by the authorities (the comparison of the result with criteria and values i.e. the proper "assessment" and the final political decision).

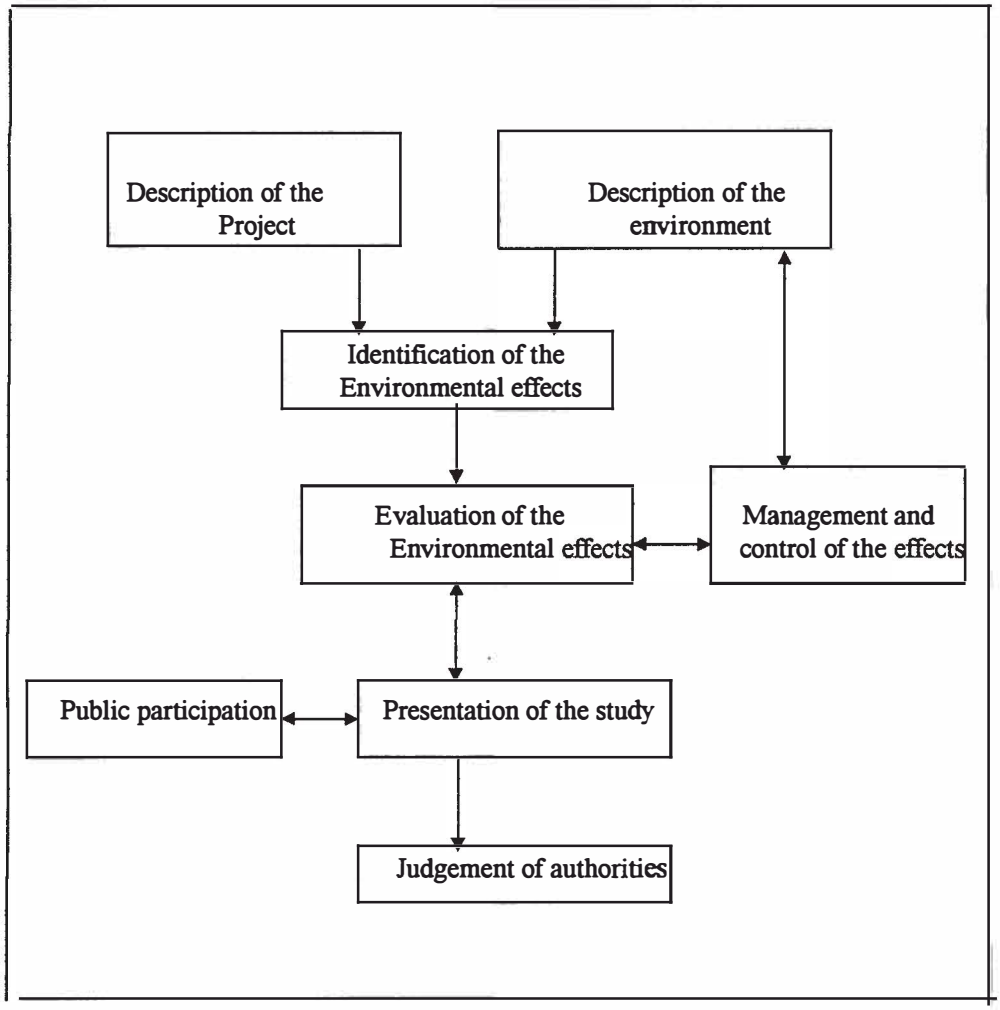

Figure 1: Main Phases of an EIA Study

Expert System (ES)

An Expert System (ES) is a class of computer programs that can advise, analyse, categorise, communicate, consult, design, diagnose, interpret, justify, learn, manage, monitor, plan, present, retrieve, schedule, test and tutor. It normally addresses problems from human specialists for their solution requirements. The basic components of an ES are expertise, expert, transferring expertise, inference rules and explanation capability. These components are defined as follows:

Expertise: Expertise is the extensive, task-specific knowledge acquired from training, reading, and experience. The following types of knowledge are examples of what expertise is. They include facts about problem area, theories about problem area, hard-and-fast rules, and procedures regarding the general problem area. They also include rules (heuristics) of what to do in a given problem situation (that is, rules regarding problem solving), global strategies for solving problems, and Meta-knowledge (knowledge about knowledge).

Expert: Is a person who has the special knowledge, judgement, experience, and methods, along with the ability to apply these talents (Durkin, 1994). Human expertise includes the following activities, as specified by Turban (1992): recognising and formulating the problem, solving the problem quickly and properly, explaining the

solution, learning from experience, restructuring knowledge, breaking rules, determining relevance, and degrading gracefully.

Transferring Expertise: The objective of an ES is to transfer expertise from the expert to a computer, then to other humans (non-expert). This process involves four activities: knowledge acquisition (from experts or other sources), knowledge representation (in the computer), knowledge inference, and knowledge transfer to users.

Inference: A unique feature of an ES is its ability to reason. Given that all the expertise is stored in the knowledge base, and that the program has accessibility to knowledge, the computer is programmed so that it can make inference; the inference engine includes procedures on problem solving.

Rules: Most commercial ES are rule-base systems, where the knowledge is stored mainly in the form of rules, as are the problem-solving procedures. The rule is in the form of: "if condition then action".

Explanation capability: Is a unique feature of an ES that has the ability to explain its advice, recommendations, and even to justify why a certain action is not recommended. The explanation and justification are done in a subsystem called the "justifier", or "the explanation subsystem".

An ES can be distinguished from a more conventional application program in that it simulates human reasoning about a problem domain, rather than simulating the domain itself. It performs reasoning over representations of human knowledge, in addition to doing numerical calculations or data retrieval, and solves problems by heuristic or appropriate methods which, unlike algorithmic solutions, are not guaranteed to succeed.

An ES can provide major benefits to users. Some of the potential benefits are as follows: increase output and productivity, increase quality, reduce downtime, capture of scarce expertise, flexibility, easier equipment operation, elimination of the need for expensive equipment, accessibility to knowledge and help desks, reliability, and increased capability of other computerised systems. Besides that, ES has an ability to work with incomplete uncertain information, enhancement of problem solving, provision of training, ability to solve complex problems, and knowledge transfer to remote locations.

Data Base Management System (DBMS)

Data Base Management System (DBMS) is essentially nothing more than computerised record keeping system. The database itself can be regarded as a kind of electronic filing cabinet; in other words, it is a repository for a collection of computerised data files. The user of the system will be given facilities to perform a

variety of operations on such files, including the following: first, creating new files to the database; also, inserting new data into existing files; next, retrieve data from existing files, in addition to updating data in existing files. Finally, deleting data from existing files and removing existing ones, empty or otherwise from the database (Date, 1995).

The advantage of a database system over traditional paper-based methods of record keeping was listed by Date (1995). First, there is no need for voluminous paper files (compactness); second, the machine can retrieve and change data faster than human (speed); third, much of the sheer tedium of maintaining files by hand is eliminated (less drudgery); last, accurate and up-to-date information is available on demand at any time (currency). On the other hand, Date (1995) listed the advantages that accrue from the notion of centralised control of data, namely: redundancy can be reduced, consistency can be avoided (to some extent), the data can be shared and standards can be enforced. Also, security restrictions can be applied, integrity can be maintained and conflicting requirements can be balanced.

Expert Database System (EDS)

Miles (1986) define an Expert Database System (EDS) as a tool for development application requiring both a DBMS and one or more ES. There are clearly many applications that require such a tool. In fact, the majority of the

applications where DBMS is currently being used today would benefit from such a tool. Accordingly, EDS is defined as "a system for developing an application requiring knowledge-directed processing that has shared information". An important aspect in the integration of Expert System (ES) and database management systems (DBMS's) technology is identifying functional similarities in database processing and reasoning with rules.

Organisations, private and public, are continuously collecting data, information and knowledge, and storing it in computerised systems. Updating, retrieving, utilising, and deleting this information become more complicated as the amount increases. At the same time, the number of individuals who use this information will increase due to networking, end-user computing and reduced cost of information processing. Working with large databases is becoming a difficult task that requires considerable expertise. The expert system is used to perform intelligent processing of information being stored in, or retrieved from, the DBMS (Miles, 1986).

Expert database systems extend the functionality of conventional database systems by providing a facility for creating and automatically executing condition-action rules. While condition-action rules in database systems are very powerful, they also can be very difficult to program, due to the unstructured and unpredictable nature of rule processing (Baralis et al., 1994). Different expert system applications require

the use of large amounts of data in conjunction with specific expertise. An ES-DBMS is a couple approach based on two distinct phases: first, a computation on the side of the ES, which, using its knowledge, generates the queries for the DBMS, and second, the execution of the queries on the side of the DBMS (Missikoff and Wiederhold, 1986).

Problem Statement

Environmental Impact Assessment (EIA) generally requires a multidisciplinary team of experts. Thus, a study may require not only engineers, but also specialists in the biology, chemical and physical sciences, besides personnel in social, medical and economic fields. In addition, there is a need of that expertise to be within the agency that is responsible for managing EIA in order to review and evaluate the generated report. Finding the manpower with necessary expertise for the above tasks would be the major problem.

Recognising and gathering relevant data for EIA study are considered as a time consuming part of an expert work. Environmental Impact Assessment (EIA) increases considerable expenses, and introduces unnecessary delays in the project implementation. Database can make the necessary information available, but current access methods require database skill, which few experts have. The recent emphasis on standardisation of methods accuracy in environment data collection and reporting

the inclusion into accessible computerised database are a positive stop toward improving environmental management.

EIA usually deals with rather complex problems that touch upon many disciplines, and rarely will an individual or a small group of individuals have all the necessary expertise at their disposal. The Expert Systems (ES) component of an EIA system helps to fill this gap; and, at the same time, takes over the role of tutor (Fedra,1994). A forecast of likely consequences and impacts has to be based on some kind of model, whether that is a mental model, a set of rules of thumb or heuristics an expert might use, or a formal mathematical model, or the necessary information to be inserted in the procedure. If no specific data is available, one has to look for similar problems where an experience exists, draw, and extrapolate upon analogies. This role is usually filled by an expert's knowledge, or by handbooks and similar sources of information.

A reliable and adequate database system needs to be established to support subsequent phases of an EIA study, that is, on prediction of impacts to the environment as a result of the proposed development. This can affect relationships between various project activities and the physicochemical, biological and human elements in the project environment and its surrounding. Hence, data gathering is not necessarily limited to the project site, but may need to be extended to the surrounding areas. This study suggests an integration of Expert System (ES) and DataBase

Management System (DBMS) technologies to produce timely and adequate EIA reports.

Objectives of the Study

The objectives of this research are:

1. To develop a database system that allows an EIA expert to manage EIA information related to EIA study, such as an existing environment where this information is collected from environment data resources, besides the information about project description. In addition, the potential impact, mitigation measures and residual impact will be collected from EIA experts, historical EIA reports and literature reviews. Database system will bring together the existing environment data and other EIA studies components to help design a key environmental data format which is available for use to any organisations which are interested in environment information.
2. To produce a set of rules which enables the expert system to be aware of the existing environment component classes and project types. The rules are developed according to the component classification characteristics.
3. To provide a way to integrate database management system and expert system whereby each system is developed individually; then the database system imports the expert system recommendations to manage its queries.

Expected Result of the Study

The expected outcome of this research is a prototype of an EIA expert database system. It can be used first by an EIA expert to store information related to EIA studies, then, the system can be used by a project proponent to prepare his\her EIA report in a short time. To save time needed to collect environmental data, descriptions of existing environment are stored in the system database. Expected potential impact, mitigation measures and residual related to environment component classes and project activities information, should also be stored in the database. This information is collected from EIA expert discussions, historical EIA reports and literature reviews. This system is expected to be very adequate, and has a friendly Graphic User Interface (GUI), as well as satisfying EIA report requirements in short time.

The expected expert database system can be used to manage existing environment data that can be used by EIA experts or any organisation concerned with environmental data. Also, the database includes information about potential impacts, mitigation measures and residual impacts related to all existing environment and project descriptions that can be used to support EIA expert predictions.