UNIVERSITI PUTRA MALAYSIA

DECISION SUPPORT SYSTEM MODEL FOR SPECIES SELECTION IN FOREST PLANTATIONS IN MALAYSIA

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By

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August 2008

Chairman : Associate Professor Mohd Hasan Selamat

Faculty : Computer Science and Information Technology

Decision Support System (DSS) is a computer technology that is used to support decision making and problem solving processes. It was first implemented in forestry in early 1980s mainly for temperate forests but few for Malaysian forests. A DSS model for forest plantation in Malaysia is therefore needed because the forest plantation programmes is rapidly taking place. The objectives of this study are to propose a specific DSS model for supporting decision making process in selecting appropriate suitable species based on site conditions and economic parameters, and to develop a prototype based on the initial designed DSS model.

In this study, four tree species were used as data samples to develop the model and these are *Azadirachta excelsa, Acacia mangium, Hevea brasiliensis* and *Tectona grandis.* An economic module was also incorporated in the model giving users the ability to make predictions on potential cost and benefit margins of the four timber species to be planted. The prototype was developed using Windows platform with Oracle JDeveloper. Java programming language was used to develop this prototype.

The development of the prototype follows the initial designed of the DSS model. A survey was also conducted using questionnaire as well as interviews to evaluate the usability of this model. Eight usability factors used in the survey include efficiency, understandability, operability, attractiveness, error prevention, learnability, accuracy and effectiveness.

Results from the survey indicated that the user satisfaction index for all usability factors of the DSS model was 0.43. This implies that the respondents were quite satisfied with the model. Furthermore, this study also shows that the factors of understandability, attractiveness and operability of the model have the highest user satisfaction index compared to other usability factors. Results from the interview session reflect some weaknesses of this model and suggestions were given to improve the model.

In conclusion, the objectives of this study which are to develop a DSS model and a prototype for Malaysian forest plantation management were achieved. The DSS model is usable to support the decision making process for commercial tree planting in Malaysia. The economic parameters gave new insight on costing and the environmental parameters also complement the DSS model. This study revealed that respondents were quite satisfied with the proposed DSS model. However, additional environmental parameters particularly slope elevation and drainage need to be included. Other tree species and the use of weighing method should also be included to improve the DSS model.

Abstrak tesis yang dikemukakan kepada Senat of Universiti Putra Malaysia sebagai memenuhi sebahagian keperluan untuk Ijazah Master Sains

MODEL SISTEM SOKONGAN KEPUTUSAN UNTUK PEMILIHAN SPESIES BAGI HUTAN LADANG DI MALAYSIA

Oleh

SHAFINAH BINTI KAMARUDIN

Ogos 2008

Pengerusi : Professor Madya Mohd Hasan Selamat

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Sistem Sokongan Keputusan (SSK) adalah teknologi komputer yang digunakan untuk menyokong pembuatan keputusan dan penyelesaian masalah. Pertama kali ia dilaksanakan dalam bidang perhutanan pada awal tahun 1980an terutamanya untuk hutan beriklim sederhana tetapi hanya sedikit untuk hutan Malaysia. Model SSK bagi hutan ladang di Malaysia diperlukan kerana program hutan ladang sedang berkembang dengan pesat. Objektif kajian ini adalah untuk mencadangkan model SSK yang spesifik bagi menyokong proses pembuatan keputusan dalam pemilihan spesies yang bersesuaian berdasarkan keadaan tempat dan parameter ekonomi, dan untuk membangunkan prototaip yang berasaskan rekabentuk asal model SSK.

Dalam kajian ini, empat spesies pokok digunakan sebagai persampelan data dalam proses pembangunan model iaitu *Azadirachta excelsa, Acacia mangium, Hevea brasiliensis* dan *Tectona grandis.* Modul ekonomi juga digabungkan dalam model ini membolehkan pengguna membuat anggaran bagi potensi margin kos dan keuntungan bagi keempat-empat spesies untuk ditanam. Prototaip yang dibangunkan

menggunakan platform Windows dengan Oracle JDeveloper. Bahasa pengaturcaraan Java digunakan untuk membangunkan prototaip ini. Prototaip ini dibangunkan berasaskan model SSK. Kaji selidik dijalankan dengan pengagihan borang soal selidik dan juga temubual dilaksanakan untuk menilai terhadap tahap kebergunaan model SSK. Lapan faktor kebergunaan digunakan dalam kaji selidik ini iaitu keberkesanan, pemahaman, operasi, tarikan, penghalang kesilapan, kebolehan belajar, ketepatan dan kecekapan.

Keputusan dari kajian ini menunjukkan bahawa indeks kepuasan pengguna bagi keseluruhan faktor kebergunaan model SSK adalah 0.43. Ini menunjukkan responden agak berpuas hati dengan model yang dicadangkan. Seterusnya, keputusan ini juga menunjukkan faktor pemahaman, tarikan dan operasi bagi model yang dicadangkan mempunyai indeks kepuasan pengguna yang tertinggi berbanding faktor kebergunaan yang lain. Keputusan dari sesi temubual memberi refleksi terhadap kelemahan model dan cadangan untuk memperbaiki model SSK diterima.

Kesimpulannya, objektif kajian untuk membangunkan model SSK dan prototaip bagi hutan ladang Malaysia telah dicapai. Model SSK membantu dalam proses pembuatan keputusan bagi penanaman pokok komersial di Malaysia. Penambahan parameter ekonomi memberikan pendekatan baru dalam penilaian kos disebalik faktor-faktor parameter alam sekitar yang juga melengkapi model ini. Hasil kajian menunjukkan responden agak berpuashati dengan model SSK. Namun begitu, penambahan parameter alam sekitar khususnya darjah kecerunan dan saliran adalah diperlukan. Spesies pokok lain dan penggunaan pemberat juga perlu untuk ditambah bagi memperbaiki model SSK.

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Finally, I would like to share this moment of happiness with my parents, my family and my beloved husband, Mohd Ikram Mohammad for their encouragement and support all these years.

I certify that an Examination Committee has met on **28 August 2008** to conduct the final examination of **Shafinah Binti Kamarudin** on her Master of Science thesis entitle **"Decision Support System Model for Specific Species Selection in Malaysian Forest Plantations"** in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the student awarded the degree of Master Science.

Members of the Examinations Committee were as follows:

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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Date: 15 January 2009

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at UPM or at any other institutions.

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SHAFINAH BINTI KAMARUDIN

Date: 28 July 2008

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LIST OF ABBREVIATIONS

4S Tool	Forest Stand Software Support System
BC ratio	Benefit-Cost Ratio
CTP	Commercial tree planting
DSS	Decision Support System
FTM	Forest Time Machine
FVS	Forest Vegetation Simulator
GIS	Geographical Information System
HAS	Hotel Advisory System
IRR	Internal Rate of Return
LUMM	Land Use Model Metronamica
MIS	Management Information System
NED	NorthEast Decision
PASS	Project Analysis and Selection System
TTPG	Texas Tree Planting Guidance
QTS	Queensland Tree Selector

CHAPTER 1

INTRODUCTION

1.1 Background

Good decision making means that the person is informed with relevant, accurate and appropriate information on which to base the choice. Information includes facts, numbers, historical data, graphics, pictures, and sounds (Sauter, 1997). A decision-making process is a method that guides an individual or group through a series of tasks from problem identification and analysis to design of alternatives and selection of an alternative (Mintzberg *et al.*, 1976; Reynolds, 2005). Decision making sometimes can be a very difficult and challenging task.

Forest management is a system of practice for stewardship and use of forest resources aimed at fulfilling relevant ecological (including biological biodiversity), economic and social functions of the forest in a sustainable manner. In forest management, forest managers are obliged with responsibilities to make decisions that might affect forest sustainable. Most of the forest managers use models to tackle problems of forest management. Models are defined as abstract representations of the real world that are useful for purposes of thinking, forecasting and decision making.

System model are tools that managers can use to predict the consequences of their actions. Although system models are mathematically formulated, both mathematics and algorithms are crucial for the system models to be functional. Algorithms have

been immensely improved by computer technology (Buongiorno and Gilles, 2003). Decision Support System (DSS) is an example of a system model that uses mathematics and algorithms. It is a computer technology solution that can be used to support complex decision making process and problem solving (Shim *et al.*, 2002).

Forest plantation management is an important component for forestry activities. Malaysia currently has 250,000 ha of forest plantations located mainly in Sabah, Sarawak, Johore and Pahang. To strengthen its commitment to the world timber market without compromising biodiversity and environmental values, Malaysia aims to increase the forest plantation area to 500,000 hectares. Thus, Malaysia timbers will be felled from a sustainably managed forest. Decision to select appropriate species to be planted in forest plantation is a difficult task faced by foresters both in the government and private sectors. In order to make a good decision, there should be proper technique to be implemented and DSS is one approach in solving this problem.

1.2 Problem Statement

Decision Support System (DSS) has played a prominent role in the implementation of sustainable forest management since the early 1980s (Reynolds, 2005). Booth (1995) mentioned that decision makers and researchers in developing countries have limited access to DSS technologies. In addition, most of the DSS technologies and applications were purposely developed or designed for temperate forests.

A developing country with huge natural forest resources such as Malaysia has limited access to DSS technologies and applications. Currently, only Geographical Information System (GIS) such as ArcView and ArcInfo are considered as DSS tools widely used by foresters in Malaysia to support their decision making. In the Department of Forestry, the decision support tools that have been used widely are Geographical Information System (GIS), GIS Interactive for Analysis and Mapping (GIAM) and Forest Recreation's Operational and Management System (FROMS). In a GIS, every record or digital object has an identified geographical location. This property is GIS's most distinguishing characteristic (Turban, 1998). Even though GIS has the ability to support decision making process it was developed only for spatial purposes. Example of usage of GIS is to support decision making for forest harvesting (Cabral, 2000).

Difficulty in selecting suitable tree species is one of the problems in forest plantation programmes in Malaysia (Lim *et. al*, 2002). DSS application is one of the solutions to help the decision makers to select the most appropriate tree species but there were no reported or documented DSS applications used for this in Malaysia. The existing DSS models such as Queensland Tree Selector (QTS) and Texas Tree Planting Guide (TTPG) have the similarity in solving the species matching problems but both models were for temperate countries and therefore not suitable for Malaysian environment.

The Queensland Tree Selector (QTS) was proposed to suit the Queensland environment in Australia. However, the design of the QTS's result page lacks the explicit explanation on the results rating. The Texas Tree Planting Guide (TTPG)

faced the difficulty in suggesting the appropriate tree species when the user considers more than two environmental parameters. Both models only consider environmental factors and are not embedded in the model with other components particularly economic parameters which are crucial in the decision making process.

1.3 Research Objectives

The objectives of this study are:

a. to propose a specific DSS model for supporting decision making process in selecting suitable tree species based on site conditions and economic parameters.
b. to develop a prototype based on the initial designed DSS model.

1.4 Research Scope

Decision Support System (DSS) Model for species selection is a model developed to reduce the problems in forest tree plantation establishment in Malaysia. Difficulty to select appropriate species is the main problem that motivates this research to be conducted. Therefore, this model was designed with the ability to help users to choose suitable tree species according to site conditions and economic parameters.

Reconstruction from previous model (Anderson *et al.*, 2005; Lexer *et al.*, 2005) and combination of information from a species matching form was applied in the development process of the model. Information on tree species was provided as user

references. Even though this study was developed for selecting tree species, economic module was also provided to help facilitate user decision making.

This study is limited to the forest plantation and only four tree species were selected as the data sample. The species are *Azadirachta excelsa*, *Acacia mangium*, *Hevea brasiliensis* and *Tectona grandis*. These species were selected because they are fast-growing industrial species and according to Ab. Rasip *et al.*, (1996) these species are among the potential species for forest plantation programmes in Malaysia.

Usability inquiry was conducted to verify that this DSS model will meet user needs. The key factors used in this usability inquiry are efficiency, learnability, understandability, operability, attractiveness, error prevention, accuracy, effectiveness and overall evaluation. The target users for this usability testing are:

a. Forest managers
b. Companies that are involved in the timber industry
c. Researchers and institutions oh higher learning

The data to verify the usability of the DSS model were collected from the Department of Forestry (Peninsular Malaysia and Sarawak), Universiti Putra Malaysia and Forest Research Institute Malaysia through questionnaire and interview sessions. Data gathered from the questionnaire were analysed by incorporating Bailey and Pearson (1983) instrument measurement as indication towards the usability level of the proposed model. Meanwhile, the interview questions were constructed to identify any usability weakness associated with the model.

1.5 Organization of the Thesis

CHAPTER 1: INTRODUCTION, a brief description of the research was discussed, followed by a discussion of the problem statement and objective of the research. The outline of the rest of the thesis is as follows.

CHAPTER 2: LITERATURE REVIEW cover the related studied on previous DSS model. This chapter introduced the DSS terminologies, characteristics and capabilities of DSS and reviews the existing DSS application for forestry.

CHAPTER 3: METHODOLOGY, the work or process flow of this research as well as methods, techniques and approach of developing DSS model were discussed. The approaches to conduct a survey for system evaluation were discussed.

CHAPTER 4: SYSTEM DEVELOPMENT, the further detail discussion on system development process which focused ob system analysis phase, system design phase, system construction and system implementation.

CHAPTER 5: SYSTEM EVALUATION, the results regarding the proposed model which obtained from questionnaires and interviews were discussed.

Overall of this research was summarized in **CHAPTER 6: CONCLUSION.** Limitation of this DSS model was listed and suggestion of future works was stated.

CHAPTER 2

LITERATURE REVIEW

2.1 Decision Support System (DSS)

In the 1960s, the major information system is the transaction processing and it became apparent that the information provided by the management information system (MIS) was adequate in supporting many decision making needs. Tian *et al.*, (2007) stated that the concept of DSS was introduced in late 1960s. The DSS are computer-based systems that bring together information from a variety of sources to assist in the organization and analysis information. The DSS technology and applications are built to support the decision making process. Below are the terminologies of DSS, its characteristics and compatibilities, and a review of the existing system in forestry.

2.2 Definition of DSS

Decision Support Systems (DSS) is one of major types of Information Systems (IS). There are many terminologies that have been used by researchers. Turban (1998) stated that the earliest concept involved in DSS was articulated in the early 1970s by Scott-Morton under the term “management decision systems” and defined DSS as an interactive computer-based system which helped decision makers utilize data and models to solve unstructured problems.

Reynolds (2005) defined DSS as a computer-based system comprising of a language system, presentation system knowledge-system, and problem-processing system which collectively can be used in decision making. A decision-making process is a method that guides an individual or group through a series of tasks of problem identification and analysis to design alternatives and selection of an alternative (Mintzberg *et al.*, 1976).

Morley and Parker (2007) defined DSS as a type of information system typically used by the management. It provides the tools and capabilities to organize and analyze decision making information. DSS was usually tailored for the needs of an individual or group and was designed to help specific type of decisions.

DSS can help managers make decisions by providing information, models, and tools for analyzing information. These systems give users good judgment in using the system and making decisions and they may provide methods and formats for portions of a decision process such as the common framework for analyzing and explaining a decision.

2.3 Characteristics and Capabilities of DSS

The following are eight characteristics and capabilities reported by Cabral (2000) in his study related to the approach of designing and developing a tactical timber harvesting planning using GIS application.