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# DEVELOPMENT OF A SPATIAL DECISION SUPPORT SYSTEM FOR LAND USE PLANNING

ELSADIG ABDALLA ALJACK

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# DEVELOPMENT OF A SPATIAL DECISION SUPPORT SYSTEM FOR LAND USE PLANNING

By

ELSADIG ABDALLA ALJACK

Thesis Submitted In Fulfilment of the Requirement
for the Degree of Doctor of Philosophy
in the Faculty of Engineering
Universiti Putra Malaysia

August 2001

UPM

**To my beloved father, mother, brothers, sisters, wife and son**

***I dedicate this work with great love and appreciation for their kindness, encouragement and strong support***

Abstract of thesis submitted to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

# DEVELOPMENT OF A SPATIAL DECISION SUPPORT SYSTEM FOR LAND USE PLANNING

By

**ELSADIG ABDALLA ALJACK**

**August 2001**

**Chairman : Dr. Ir. Mohamed Daud**

**Faculty : Engineering**

Land use planning and management have an obvious spatial dimension where complex models and methods of assessment are used. The use of information technologies and spatial concepts promise many benefits to planners and decision-makers in the land use planning process. However, current land use planning systems lack flexibility in accommodating changes of land use parameters. This prevents decision makers from generating alternate land use scenarios. This research aims to develop a flexible Spatial Decision Support System for Land use Planning (SDSS-LP). The SDSS-LP development lifecycle methodology consists of five phases, namely, planning, analysis, design, implementation and testing phases. SDSS-LP was developed in the modules by using ArcView programming language Avenue and dialog designer extension. The system modules are categorized into three subsystems

i.e. database management, analysis and modeling. The system permits decision-makers to view and access its own planning domain database without any constraints. Next, SDSS-LP also helps the decision-makers to manipulate and analyze spatial and attribute data so as to be able to decide on significant suitability factors. These factors will facilitate the production of alternative allocation maps that can be used to represent different planning scenario. Thus, the SDSS-LP is valuable software that can be used within the land use planning process.

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

# PEMBANGUNAN SISTEM SOKONGAN MEMBUAT KEPUTUSAN SPATIAL BAGI PERANCANGAN GUNATANAH


Oleh

**ELSADIG ABDALLA ALJACK**


**Ogos 2001**


**Pengerusi : Dr. Ir. Mohamed Daud**

**Faculti : Kejuruteraan**



Pengurusan dan perancangan guna tanah mempunyai lokasi dimensi yang nyata dan menggunakan model yang kompleks serta kaedah penilaian. Penggunaan teknologi maklumat dan konsep lokasi yang menjanjikan banyak manafaat kepada perancang dan pembuat keputusan dalam proses perancangan guna tanah. Bagaimanapun, sistem perancangan guna tanah masa kini kurang stabil dalam pertukaran kerja bagi parameter guna tanah. Ini menghalang pembuat keputusan dari menghasilkan senario penggunaan tanah yang berulang-ulang. Kajian ini bertujuan untuk membina satu system sokongan keputusan lokasi (Spatial Decision Support System) bagi Perancangan Guna Tanah (SDSS-LP). Pembinaan SDSS-LP terdiri daripada lima fasa, iaitu perancangan, analisis, rekabentuk, perlaksanaan dan fasa percubaan. SDSS-LP direka dalam bentuk modul dengan menggunakan program

ArcView bahasa Avenue (Avenue Language) dan penghubung rekaan dialog (dialog designer extension). Modul sistem ini dikategorikan kepada tiga subsistem, iaitu pengurusan pengkalan data, analisis dan model subsistem. Sistem ini membenarkan pembuat keputusan untuk melihat dan menggunakan perancangan aktiviti pengkalan data tersendiri tanpa sebarang had. SDSS-LP juga membantu pembuat keputusan untuk mengurus dan menafsir lokasi dan menentukan data yang akan digunakan, oleh itu ia boleh menyediakan satu faktor keputusan bermakna yang bersesuaian. Faktor ini akan memudahkan penghasilan pilihan pembahagian peta dimana ianya boleh digunakan untuk menunjukkan senario guna tanah yang berbeza. Jadi SDSS-LP boleh menjadi alatan komputer (software) yang bernilai, dimana ia boleh digunakan dalam proses perancangan guna tanah.

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Last but not least, I am thankful to my parents, brothers, sisters, wife, son and relatives for their understanding, patience and strong support, which have always been a source of inspiration and strength throughout my life. However, it was their subtle encouragement that kept me going.

I certify that an Examination Committee met on 1st August 2001 to conduct the final examination of Elsadig Abdalla Aljack on his Doctor of Philosophy thesis entitled "Development of a Spatial Decision Support System for Land use Planning" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

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

ELSADIG ABDALLA ALJACK
Date: 11/08/2001

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| | |
|---|---|
| DBMS | Data Base Management System |
| DSS | Decision Support System |
| FAO | Food and Agriculture Organization |
| GIS | Geographical Information System |
| GUI | Graphical User Interface |
| KBS | Knowledge-Based System |
| LIS | Land Information System |
| MACRES | Malaysian Center for Remote Sensing |
| MCDM | Multiple Criteria Decision Making |
| MCE | Multi-Criteria Evaluation |
| MDBS | Model Base Management System |
| PSS | Planning Support System |
| SDSS | Spatial Decision Support System |
| SDSS-LP | Spatial Decision Support System for Land use Planning |
| SEPSS | Socio-Economic Planning Support System |
| WLC | Weighted Linear Combination |

# CHAPTER 1

# INTRODUCTION

## Background

The primary purpose of this research was to develop a spatial system to support decision making in land use planning process by offering a flexible tool that allows decision makers to change planning parameters so as to produce several land use scenarios. For many years, computer applications have been used to facilitate the land use process especially data management and analysis. However, these applications were fixed with some of land use plan process parameters such as data sets, land use types, suitability factors, and factors weights and rates. These constrains have been making the process of generating land use plan alternatives very complicated. This system was developed to give flexibility and convenience to the users more than other land use applications software offers. It was developed using Arc/View software programming language Avenue and dialog designer extension of Arc/View.

Land resources are limited and finite. Land use planning is the systematic assessment of land and water potential, alternatives for land use, and economic and social conditions, in order to select and adopt the best land use options (Food and Agriculture Organization of the United Nation, 1993). Planning involves a variety of

activities undertaken at different spatial scales by national, regional or local organization (Scholten and Stillwell, 1990). Land use planning and management have an obvious spatial dimension where complex models and methods of assessment are used. Information technology now permits us to improve acquisition, distribution, and utilization of geographic data and mapping.

The use of information technologies and spatial concepts promises many benefits to planners and decision makers in land use planning process. Computer technology, due its ability to provide answers at a high speed, can be used to transform masses of raw data into more comprehensive aggregates in a short time such that the information needed by planners and decision-makers are available more quickly and easily. Land use planning and design, site selection, and other problems requiring the manipulation of geographic information have benefited from recent advances in GIS (Wright, 1990).

Sang-Yun and Kim (1990) stated that urban planning starts with data and information, because these sources describe the conditions of the real world from which planners try to achieve the aspirations and goals of society. So, to manage planning data and information, Geographical Information Systems (GIS) provide an integrated set of tools for handling and analyzing large volumes of spatially referenced data and potentially provide a useful framework for analyzing complex space-time processes (Eric, 1999).

To assist land use planning decision-making process, Decision Support Systems (DSS) are designed to solve ill or semi-structured problems, i.e. where objectives cannot be fully or precisely defined such as land use planning. Yeh (1999) stated that, the DSS concept was extended to the spatial context in the development of SDSS; SDSS help decision-makers to make decisions on different location alternatives. SDSS are explicitly designed to support a decision research process for complex spatial problems. SDSS provide a framework for integrating database management systems with analytical models, graphical display and tabular reporting capabilities, and the expert knowledge of decision-makers (Densham, 1991).

## Problem Statement

Many people are involved in planning and making decisions about land use. They work in national, state, district, and local organizations. They include ministers, administrators, technical specialists, developers, and planners. They introduce a wide range of skills and experience to carry on land use planning. Effective land use plans take into consideration various factors, some of which seem unrelated to the problem of land use. The most important of these considerations are diversity of human wants, fixed nature of land resources, diversity of capabilities and suitability of landscape units, complexity of environmental attributes and uncertainties surrounding the decision problem (Scholten and Stillwell, 1990).

Once the digital computer was developed half a century ago, applications in public planning and management became widespread. GIS is increasingly accessible to the planners besides DSS and SDSS. The suitability and allocation techniques applications started in the 1960s and 1970s, in an area of limited computing power, small datasets, and rudimentary computer graphics. In the recent years, progress has been made towards solving complicated suitability and allocation problems by using GIS and other technologies which provide richness of the data and the visual quality of the computer environment for data exploration, investigation of scenarios and decision support (e.g. Despotakis et al. 1992, Jankowski and Richard 1994, Lin et al. 1997, Makropoulos et al. 1999). However some limitations exist with respect to the technical functionality of current systems.

One of these limitations is that many of the applications were produced their land use plan output using overlay and other GIS functions without developed systems that may be used by other users (e.g. Zipperer and Andersen 1991, Miller et al. 1998, and Faber et al. 1998). Bright (1997) reported a model called "ALLOT" to perform land suitability and allocation for various future land use types. In spite of the fact that the model is a step forward, nevertheless, the model fixed land use types and suitability factors, and factor weights. One of the remarkable computer based systems in land use planning is Klosterman (1999) system, which provided a complete package for planning support system. However he fixed suitability factors and their related factor types. Therefore, the problem statement for this research is

stated as "current land use planning systems lack the flexibility in accommodating changes of land use parameters". This limitation prevents decision makers from generating alternate land use scenarios.

Land use planning is the systematic assessment of land and water potential, alternatives for land use, and economic and social conditions, in order to select and adopt the best land use options. Its purpose is to select and put into practice those land uses that will best meet the needs of people while safeguarding resources for the future (Food and Agriculture Organization of the United Nation, 1993). Consequently, the way in which planning activities are performed is not static over time. Each time period is dominated by a kind of issues, which emphasizes land use plan objectives and parameters. Planning activities are often of a non-route character and the policy making process knows many irrational moments. The planning issues change according to existing political priorities and community needs. Land use planning can be applied at three broad levels: national, district and local. Different kinds of decisions are taken at each level. Land is not same everywhere; different area presents different opportunities and management problems. All this requires a level of flexibility that most of information systems cannot yet reach. The ideal system to support land use planning process should be very flexible to accept all these differences in order to support system users to produce several land use plan alternative scenarios. The system has to allow a system user to change data set, suitability factors, factors weight and rates, and land use allocation demand and priority.

## Motivation

The most important research issues, which motivate the author to undertake this research, are as follows:

- The author is a member of Knowledge Engineering for Safety, Health and Environment Research Group, Faculty of Engineering, University Putra Malaysia. This research group takes interest in developing computer systems in fields of safety, health, and environment. The physical development has the direct impact on the environment. This matter motivated the author to develop this system so as to support planning teams to allocate land use types on the most suitable location. Thus, the system assists decision-making process by facilitating the allocation of land to the uses that provide the greatest sustainable benefits.

- The current state of the art certainly indicates that GISs are increasingly used in both the public and private sectors. However, the systems seem to be used primarily for data storage and graphic output (Harry, 1997). There is an increasing awareness of the need to develop new tool and modules within GIS environment to perform several types of spatial analysis and modeling in the fields of planning, environment, engineering and business as well. Therefore, system analysts and information technology people are encouraged to conduct