UNIVERSITI PUTRA MALAYSIA

APPLICATION OF ANALYTIC NETWORK PROCESS AND GIS FOR EVALUATING INTEGRATED COASTAL LAND USE IN KUALA LANGAT DISTRICT, SELANGOR, MALAYSIA

SHAREH POUREBRAHIM ABADI

APPLICATION OF ANALYTIC NETWORK PROCESS AND GIS FOR EVALUATING INTEGRATED COASTAL LAND USE IN KUALA LANGAT DISTRICT, SELANGOR, MALAYSIA

By

SHARAREH POUREBRAHIM ABADI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

May 2008

This Thesis is dedicated to

Mr and Mrs Irvash

My Husband, Mehrdad

My Son, Parsa, My parents and my sister

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

APPLICATION OF ANALYTIC NETWORK PROCESS AND GIS FOR EVALUATING INTEGRATED COASTAL LAND USE IN KUALA LANGAT DISTRICT, SELANGOR, MALAYSIA

By

SHARAREH POUREBRAHIM ABADI

May 2008

Chair: Professor Mohd Ibrahim Hj Mohamed, PhD

Faculty: Environmental Studies

Coastal lands are increasingly threatened by short-sighted planning policies that have focused on human activities rather than the systems sustaining them. Evaluation of coastal land uses for sustainable development involves the identification of the most important criteria and indicators. Analytic Network Process (ANP) is a new method that has potential application in the field of coastal land use development. The purpose of this research was to develop an integrated approach for evaluating the suitability of different kinds of land uses in the coastal area for sustainable development. The coastal area of Kuala Langat District, Selangor, Malaysia, was selected as the study area. There were two main objectives in this research. The first was to identify the most important criteria for coastal land use development and the second was to find the optimal land utilization suitability based on different planning scenarios. Two different approaches were applied to achieve these objectives. For the first objective, the approach employed was multi criteria evaluation using Analytic Network Process by expert opinion. For the second objective, the spatial scenario

evaluation using ARCGIS software was adopted. Three scenarios residing on economic and social development, environmental conservation and sustainable development were defined and evaluated. Four land uses, namely, residential, conservation, tourism and industry were considered. Through evaluation of the scenarios, existing plans and guidelines, land availability and investigation of current land uses and the optimum suitability for sustainable coastal land use development were proposed.

The research has demonstrated an innovative reliable method for identification of the best criteria using ANP and expert opinion. This is the first time ANP has been used for criteria development in coastal land use planning. A new software with the capability of choosing the best criteria for ANP was also developed. The current and future project patterns of growth till the year 2020 were analyzed. The GIS database for the study area was developed for scenario analysis. This analysis has resulted in a series of suitability maps for conservation, tourism, residential and industrial development. However, considering the sustainable development scenario, only one optimal land suitability map was recommended, based on criteria obtained from ANP and expert knowledge. The spatial scenario planning framework developed in this research is an example of an effective integrated decision-making framework. This research has successfully managed to identify and develop a scientifically based method to find the optimal land suitability for sustainable development in coastal land uses. The integration of social, economic and environmental criteria within the planning framework has provided an efficient spatial approach for coastal land use development. It is hoped that this ANP based approach can be employed in land use suitability assessments at both the local plan and structure plan level.

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

APLIKASI PROSES RANGKAIAN ANALISA DAN SISTEM MAKLUMAT GEOGRAFI UNTUK MENILAI GUNATANAH PERSISIRAN PANTAI YANG BESEPADU DI DAERAH KUALA LANGAT, SELANGOR , MALAYSIA

Oleh

SHARAREH POUREBRAHIM ABADI

Mai 2008

Pengerusi: Professor Mohd Ibrahim Hj Mohamed, PhD

Fakulti: Pengajian Alam Sekitar

Tanah persisiran pantai semakin diancam oleh polisi perancangan yang tidak begitu mendalam, yang telah menfokuskan pada aktiviti manusia berbanding dengan system yang menyokongnya. Penilaian gunatanah persisiran pantai untuk pembangunan lestari melibatkan pengenalpastian kriteria-kriteria dan penunjuk-penunjuk yang paling mustahak. Proses Rangkaian Analisa (Analytical Network Process -ANP) ialah satu kaedah yang mempunyai aplikasi berpotensi dalam bidang pembangunan gunatanah persisiran pantai. Tujuan penyelidikan ini ialah untuk membangunkan satu pendekatan bersepadu untuk menilaikan kesesuaian pelbagai jenis gunatanah dalam kawasan persisiran pantai bagi tujuan pembangunan lestari. Tanah persisiran pantai daerah Kuala Langat, Selangor, Malaysia telah dipilih sebagai kawasan kajian. Penyelidikan ini terdiri daripada dua objektif utama. Yang pertama ialah untuk mengenalpasti kriteria-kritetia yang paling penting untuk pembangunan gunatanah persisiran tanah pantai; dan yang kedua ialah untuk mencari kesesuaian gunatanah yang optima berasaskan senario-senario perancangan yang berbeza. Dua pendekatan

yang berlainan telah diguna untuk mencapai objektif-objektif tersebut. Untuk objektik pertama, pendekatan yang diguna ialah penilaian pelbagai kriteria dengan penggunaan ANP melalui pendapat-pendapat pakar. Bagi objektif kedua, penilaian scenario ruang dengan perisian ARCGIS telah digunakan. Tiga scenario berasaskan pembangunan socio-ekonomi, pemeliharaan alam sekitar dan pembangunan lestari telah didefinasikan dan dinilai. Untuk tujuan ini empat jenis gunatanah telah dipertimbangkan, ialah penempatan, pemeliharaan, pelancongan dan industri. Melalui penilaian senario-senario, pelan-pelan dan garispanduan-garispanduan yang sediaada, tanah yang sediaada dan penyiasatan gunatanah sekarang, kesesuiaan optima gunatanah persisiran pantai yang lestari telah kemukakan. Penyelidikan telah menunjukkan satu kaedah yang innovatif untuk pengenalpastian kriteria-kriteria dengan penggunaan ANP dan pendapat-pendapat pakar. Ini adalah kali pertama ANP digunakan untuk pembangunan kriteria-kriteria dalam perancangan gunatanah persisiran pantai. Satu perisian baru dengan kebolehan memilih kriteria-kriteria yang terbaik untuk ANP telah juga dibangunkan. Berasaskan analisa corak-corak pertumbuhan gunatanah yang lalu, corak pertumbuan masa depan sehingga tahun 2020 dapat di ramalkan. Pengkalan data GIS telah di bangunkan untuk analisa senario. Analisa ini telah menghasilkan siri peta-peta kesesuaian bagi tujuan pemeliharaan, pelancongan, penempatan dan pembangunan industri. Walaubagaimanapun dari segi senario pembangunan lestari hanya satu peta kesesuaian tanah yang optima telah dicadangkan berasakan ANP dan pendapat-pendapat pakar. Rekabentuk perancangan ruang yang dibangunkan dalam penyelidikan ini merupakan satu contoh rekabentuk pembuatan keputusan yang berkesan dan bersepadu. Penyelidikan ini telah mengenalpasti dan membangunkan satu kaedah berasaskan sains untuk mencadangkan kesesuaian tanah yang optima

bagi pembangunan lestari gunatanh persisiran pantai dengan jayanya. Intergrasi kriteria-kriteria sosial, ekonomi dan alam sekitar dalam rekabentuk perancangan telah memberikan satu pendekatan ruang yang cekap bagi tujuan pembangunan gunatanah persisiran pantai. Adalah diharapkan bahawa pendekatan berasaskan ANP ini dapat digunakkan dalam penilaian kesesuaian gunatanah pada tahap pelan tempatan dan pelan struktur.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my deep thanks to my unique husband for his support and encouragement while I completed the PhD.

I owe deep gratitude to my supervisor Prof. Mohd Ibrahim Hj Mohamed for his continual intellectual guidance and support over the last three years. I am greatly and will ever indebted to Associated Prof. Dr Zelina Zeiton Ibrahim for her critical comments and Prof. Mazlin Mokhtar for his consistent support and facilitating all necessaries during my study time.

Many other people have also given invaluable advice and assistance at different stages of this research. It would be very unwise without mentioning Eng. Kamalruddin Shamsudin and Dr. Dahlia for their collaboration for data collection and solving specific problems in urban planning and environmental science and their great advises. Also, I would like to thanks Eng. Shaharudin Idrus and for his great GIS advises and the useful data. I am very gratitude to Eng. Arpaii and staffs of Majlis Daerah Kuala Langat for their kind cooperation to do surveying during a workshop.

It would be very unwise without mentioning Mr. and Mrs Irvash for my troubles and their major supports in our life. They are in my mind for ever. I was very far from my mother and father, but their remembrance always strengthened me to solve all problems. My parents and my sister are usually the most sincere appreciated. I should also specially thank Mr. Baktiari, Ms. Zalina, Mr. Paknahad and Mr. Rostami and the experts interviewed during the research. Thanks for their support.

I certify that an Examination Committee has met on **26 May 2008** to conduct the final examination of **Sharareh Pourebrahim Abadi** on her **Doctor of Philosophy** thesis entitled " **Integrated coastal land use development using Analytic Network Process and GIS: Case of Kuala Langat District, Selangor, Malaysia**" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the student be awarded the Doctor of Philosophy degree.

Members of the Examination Committee are as follows:

Mohd Bakri Ishak, PhD
Associate Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Chairman)

Azizi Haji Muda, PhD
Associate Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Internal Examiner)

Ahmad Rodzi Mahmud, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Ahris Yaakup, PhD
Professor
Faculty of Built Environment
Universiti Technology Malaysia
(External Examiner)

_____

HASANAH MOHD. GHAZALI, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

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

Mohd Ibrahim Hj Mohamed, PhD
Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Chairman)

Zelina Zeiton Ibrahim, PhD
Associate Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Member)

Mazlin Mokhtar, PhD
Professor
Institute for Environment and Development (LESTARI)
Universiti Kebangsaan Malaysia
(Member)

AINI IDERIS, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 14 August 2008

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 Universiti Putra Malaysia or at any other institution.

_____

SHARAREH POUREBRAHIM ABADI

Date: 26 May 2008

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

9MP	9th Malaysia Plan 2006-2010
DID/JPS	Department of Irrigation and Drainage/ Jabatan Peparitan dan Saliran, Malaysia
DOE	Department of Environment, Malaysia
DOS	Department of Statistics, Malaysia
DANCED	Danish Cooperation for Environment and Development
EPU	The Economic Planning Unit, Malaysia
ICZM	Integrated Coastal Zone Management
JPBD	Jabatan Perancangan Bandar dan Desa / Town and Country Planning Department, Malaysia
LESTARI	Institute Alam Sekitar dan Pembangunan/ Institute for Environment and Development, Malaysia
LUAS/ SWMA	Lembaga Urus Air Selangor/ Selangor Waters Management Authority, Malaysia
NAP 3	Third National Agriculture Policy, Malaysia
NEP	Malaysia's National Environment Policy
NOD	Objectives National Oceanography Directorate, Malaysia
NOSCP	Malaysian National Oil Spill Contingency Plan
NPBD	Malaysia's National Policy on Biological Diversity
OECD	Organisation for Economic Co-operation and Development
OPP	Outline Perspective Plan 2001 – 2010, Malaysia
PAGE	Pilot Analysis of Global Coastal Ecosystems
PEMSEA	GEF/UNDP/IMO Regional Program on Building Partnerships in Environmental Management for the Seas of East Asia
UKM	Universiti Kebangsaan Malaysia
UNEP	United Nations Environment Programme

CHAPTER 1

INTRODUCTION

1.1 Background

The coastal zones are important boundaries in the natural system as they form the transition areas between terrestrial and marine environments (Douven *et al*., 2003). Malaysia has about 48,000 km of coastline and about 70% of the Malaysian population live in the coastal zone. The coastal areas of Peninsular and East Malaysia are historically the locations for early human settlements and trading activities (EPU and DANCED, 1999). With rapid population growth and economic activities, town planning in those days were arbitrary with rather unhealthy with unsanitary conditions (Mazlin *et al*., 2003). The competition between coastal ecosystems and human activities along the coastal zones has resulted in some environmental degradation having a negative impact on the economic and social value of the coast (Tang *et al*., 2005). There are also institutional issues such as lack of trained human resource, insufficient legal provisions for the coastal land planning, inadequate implementation of existing policies, legislation and guidelines, poor link between science and policy making and the lack of financial resources for coastal zone management (EPU and DANCED, 1999).

It needs some integrated approaches designed for the unique requirement of sustainable coastal land use development (Vollenweider, 1992; Turner, 2000; Sarda, 2005). Some new techniques such as development of decision-support systems for evaluating the current state and predicting future trends in coastal areas (Ballinger

and Smith, 1994; Fabbri, 2006; Fedra, K., 2003; 2007) and some new methods such as Analytic Network Process (ANP) (Saaty, 2004) and computer based planning tools like GIS can assist to the integration, analysis and interpretation of information (Boorquez *et al*., 2001; Ayad, 2004).

1.2 Problem Statement

Coastal lands are increasingly threatened by short-sighted planning policies that have focused on human activities rather than the systems sustaining those (Shi *et al*., 2004). Malaysia has envisioned becoming a developed country by the year 2020. So lands are being developed very fast through establishments of residential, industrial and commercial centers. Kuala Langat district as the case study is located in the strategic area, because this area is identified as a Klang Vally II. The district has been experiencing rapid development, influence by some fast growing new centers like Kuala Lumpur International Airport, Klang Valley, Cyberjaya and Putrajaya. These have caused degradations of the natural habitats located in this area such as forests, peat swamp, mangroves and wetlands and land use changes from forest and agriculture to development areas. Also some sensitive area such as reclaimed lands, geo-disaster area, flash flood prone areas, dumping grounds and high erosion area need urgent sustainable plan for future development.

On the other hand, an important goal in geo-environmental evaluation is to provide assistance to policy makers, planners and developers in planning the optimal development of an area while simultaneously preserving the environment. The draft district local plan for this area are being prepared by on going projects under the

auspices of the Department of Town and Country Planning and the results of this study could surely enhance this planning process of the study area. The evaluation results can assist planners in making decisions on land use alternatives for specific land parcels (Dai *et al*., 2001). Evaluation of the sustainability in coastal land use needs to identify specific criteria and indicators. It is quite difficult to interpret criteria for sustainable land use development in the local level without any adaptation and translation of issues.

There is a need to design integrated approaches for sustainable coastal land use development, applying techniques such as multi-criteria analysis and supporting tools like GIS to help bridge the gap between town and country planning process and coastal zone planning (Brody *et al*., 2004).

1.3 Significance of the Study

In the Ninth Malaysia Plan, one of the strategic thrust for addressing environmental and natural resources issues will focus on developing suitable sustainable development criteria. Also the Town and Country Planning Act, 1976 (Act 172) with its latest amendment in year 2001, has manifested the concern of adopting the Geographical Information System (GIS) in the development planning process, especially in the preparation of development plans.

It becomes necessary to suggest a complete methodology to develop and identify criteria for evaluation of coastal land use development. The planning framework developed in this research is referred to as spatial scenario planning framework.

Comprehensive criteria in the fields of economic, environmental and social were considered and the most important criteria were selected to be used practically in the process of spatial planning. This study uses appropriate tools like GIS and Multi Criteria Evaluation with experts' knowledge in the fields of environment, social and economy to propose a suitable plan for integrated coastal land use development. This framework is useful for efficient planning of future coastal land uses. In addition it is also useful to analyze change patterns in the past to project suitable land uses for the future and essentially this approach has been employed in the study area.

Based on the Malaysian Town and Country Planning Act 1976 (Act 172) last amended in 2001, the development plans provide the development framework and guidelines which need to be continually updated according to the present statues of development. Figure 1.1 shows the link of the study input in overall planning process. The outputs of this study can assist in making judicious decisions for future development of the study area.

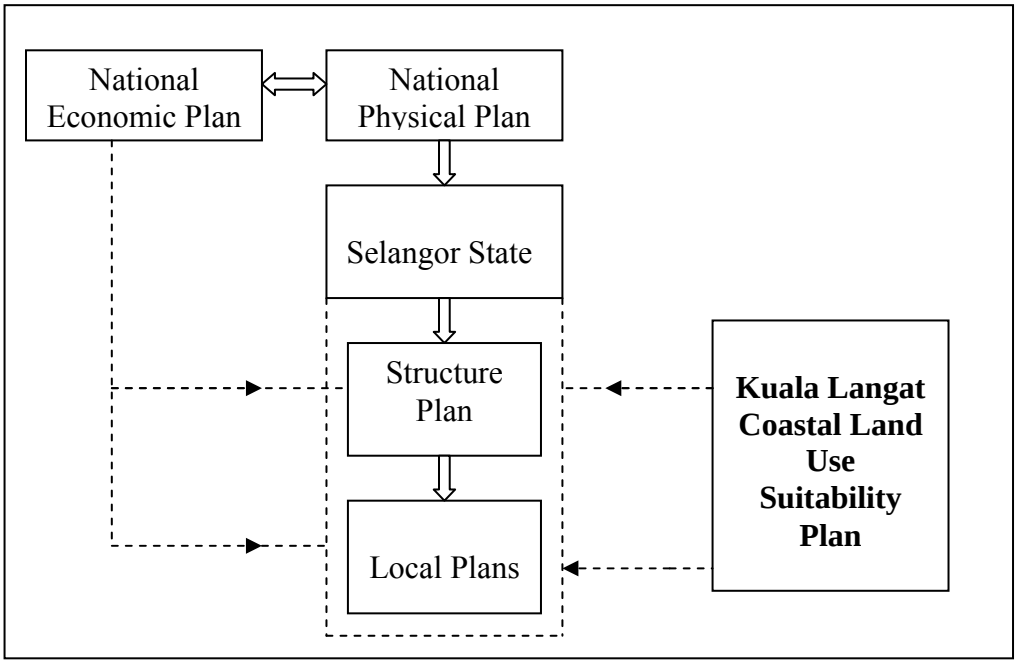

Figure 1.1. Link of the Study Output in the Planning Process

This research formulates an integrated approach for finding the optimum land use suitability for future sustainable development in the coastal area. In the process of identifying socio-economic and environmental criteria, involving the expert opinion from beginning with the analytical capabilities of the Analytic Network Process (ANP) has become a useful tool box. The use of GIS-based decision making, definition and evaluation of different scenarios for future development of land uses in coastal areas has strengthen further this research approach compared to other researches. The methodology is expected to be brief with a set of guidelines and recommendations for organizing and expressing the complexities found in coastal fringes. To-date there is no published applications of ANP in spatial planning of coastal land uses and related fields.