



UNIVERSITI PUTRA MALAYSIA

**APPLICATION OF GEOSPATIAL MULTIPLE CRITERIA DECISION
ANALYSIS IN SITING COMBINED CYCLE POWER PLANT IN IRAN**

SIAVASH EGHBALI

ITMA 2011 2

**APPLICATION OF GEOSPATIAL MULTIPLE CRITERIA DECISION
ANALYSIS IN SITING COMBINED CYCLE POWER PLANT IN IRAN**

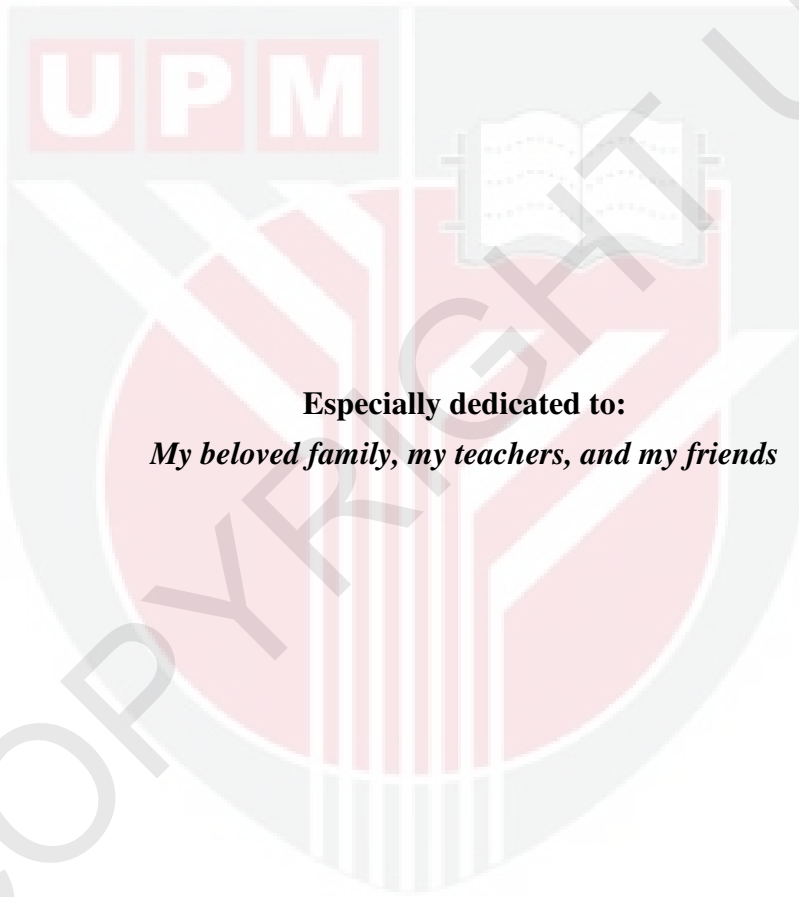


By

SIAVASH EGHBALI

**This thesis submitted to the school of graduate studies, Universiti Putra Malaysia, in
fulfilment of the requirement for the Degree of Master of Science**

March 2011



Especially dedicated to:
My beloved family, my teachers, and my friends

Abstract of thesis presented to the senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

APPLICATION OF GEOSPATIAL MULTIPLE CRITERIA DECISION ANALYSIS IN SITING COMBINED CYCLE POWER PLANT IN IRAN

By

SIAVASH EGHBALI

March 2011

Chairman: Associate Professor Ahmad Rodzi Mahmud, PhD

Faculty : Institute of Advanced Technology

Establishment of a power plant as a main infrastructure requires comprehensive investigation prior to construction phase. Location of power plant is one of the main issues which should be inspected in advance to guarantee its future optimized operation and minimized losses. This study uses the integration of Geographic Information System (GIS) and Multi Criteria Decision Analysis (MCDA) approach to site a Combined Cycle Power Plant (CCPP). This research was implemented in three successive stages which include a small scale map (1:250,000) and a large scale map (1:25,000) site suitability assessments, and a site selection. In the first stage, a site suitability assessment was performed to determine the high potential area in Sistan and Baluchistan province in Iran for CCPP establishment using small scale map (1:250,000). This stage involves a number of processing steps which include: definition of influential siting criteria, relative classification and constraint zones determination, evaluation criteria prioritization (PWC method) and factor maps integration (WLC method). The final

result of this stage showed that around 0.03% of province area possesses the highest potential for CCPP establishment. After imposing constraint map, it was found that the north zone of Chabahar port is the only most potential area which is feasible for CCPP construction. In next stage, based on the highest potential area of 1:250,000 scale analysis, the same steps of site suitability assessment were implemented to obtain the highest potential regions using 1:25,000 scale map. The result illustrates that around 12% of study area had the highest potential for CCPP establishment. Afterward, by imposing final constraint map and CCPP areal limitation, 3 alternatives were designed as final candidate sites for CCPP establishment. In the final stage, a spatial decision making was performed to determine the best site for CCPP placement and the result shows that Site 1 is the best site for its establishment. For evaluating the robustness of final result, a sensitivity analysis was performed based on two criteria weights as the most controversial. The sensitivity analysis results confirmed the persuasive stability of final result against perturbation in criteria weights. The experts' opinions in all stages agreed on high importance of water and fuel provision in locating the CCPP establishment site. Also the measuring index for the load demand criterion which is the load demand growth in previous studies emerged incomplete and was replaced by the load demand density.

Abstrak tesis dikemukakan kepada Senat Universiti Putra Malaysia untuk memenuhi keperluan ijazah Master Sains

**PENGGUNAAN ANALISIS KEPUTUSAN PELBAGAI KRITERIA
GEOSPATIAL BAGI PENENTUAN LOKASI PEMBINAAN LOJI KUASA
KITARAN BERGABUNG DI IRAN**

oleh

SIAVASH EGHBALI

Mac 2011

Pengerusi: Profesor Madya Sr. Ahmad Rodzi Mahmud, PhD

Fakulti: Institut Teknologi Maju, UPM

Pembinaan loji kuasa sebagai infrastruktur utama memerlukan kajian menyeluruh sebelum proses pembinaan dimulakan. Lokasi loji kuasa merupakan salah satu isu utama yang harus diselidiki terlebih dahulu untuk memastikan operasi pada masa hadapan dapat dioptimumkan dan kerugian dapat diminimumkan. Kajian ini menggunakan kerangka bersepadu antara Sistem Maklumat Geografi (Geographic Information System - GIS) dan pendekatan Analisis Keputusan Pelbagai Kriteria (Multi Criteria Decision Analysis - MCDA) bertujuan menentukan tapak untuk mendirikan Loji Kitaran Kuasa Bergabung (Combined Cycle Power Plant - CCPP). Penyelidikan ini dilaksanakan pada tiga tahap secara berurutan, iaitu melibatkan peta skala kecil (1:250.000) bagi penilaian kesesuaian tapak loji, dan peta skala besar (1:25,000) bagi penilaian kesesuaian dan pemilihan tapak loji. Pada tahap pertama, penilaian kesesuaian tapak dilakukan untuk menentukan kawasan yang berpotensi tinggi di wilayah Sistan untuk mewujudkan CCPP. Tahap ini merangkumi beberapa langkah pemprosesan,

meliputi tafsiran kriteria penentuan tapak yang positif, zon dalam klasifikasi relatif dan kendalaan, penilaian kriteria keutamaan (kaedah PWC), dan faktor integrasi pemetaan (kaedah WLC). Keputusan akhir pada tahap ini menunjukkan bahawa kira-kira 0.03% kawasan wilayah mempunyai potensi tertinggi untuk mendirikan CCPP. Setelah mengambil kira petunjuk kendala, didapati bahawa zon utara pelabuhan Chabahar merupakan satu-satunya daerah yang paling berpotensi untuk mendirikan CCPP. Pada tahap seterusnya, dengan menggunakan daerah berpotensi tertinggi yang ditentukan pada tahap sebelumnya, langkah yang sama bagi penilaian kesesuaian tapak telah dilaksanakan untuk mendapatkan kawasan yang berpotensi tertinggi pada peta berskala 1:25,000. Keputusan ini menunjukkan bahawa 12% daerah kajian mempunyai potensi tertinggi bagi pembinaan CCPP. Setelah itu, petunjuk akhir kendalaan dan keterbatasan kawasan CCPP diambil kira, dan didapati bahawa tiga alternative telah dicadangkan sebagai tapak untuk pilihan akhir bagi pembinaan CCPP. Pada tahap akhir, proses membuat keputusan dilakukan untuk menentukan lokasi terbaik untuk mendirikan CCPP dan hasilnya menunjukkan bahawa Tapak 1 merupakan tapak terbaik untuk pembinaannya. Untuk menilai kekukuhan keputusan akhir, analisis sensitiviti dilakukan terhadap dua kriteria yang dianggap sebagai yang paling kontroversial. Keputusan analisis sensitiviti mengesahkan bahawa kriteria kestabilan bagi keputusan akhir yang diragui mengatasi kriteria gangguan. Para pakar dalam semua tahap sependapat bahawa kesediaan pembekalan air dan bahan bakar yang tinggi penting dalam mencari tapak pembina CCPP. Juga indeks pengukuran berdasarkan kriteria jumlah permintaan yang bergantung pada peningkatan jumlah permintaan dalam kajian dahulu ternyata tidak lengkap dan harus digantikan dengan kepadatan jumlah permintaan.

ACKNOWLEDGEMENTS

Praised God for his help and guidance on me since the beginning, during, and till the completion of this thesis. This work would have not been accomplished without the help of my supervisory committee, family, and friends.

My profound gratitude goes to the chairman of my supervisory committee, Assoc. Prof. Dr. Ahmad Rodzi Mahmud, for his valuable guidance, support, and encouragement during my study. His professional review has helped this thesis to be improved. Similarly, I would like to express my sincere gratitude to Assoc. Prof. Dr. Abdul Rashid Mohamed. Shariff for his comments and helps which has enhanced this thesis methodology. His technical review transformed this thesis into a readable form.

Also I would like to thank Ministry of Energy of Iran staff from different departments specially Mr. Samadi, Mr. Taghdisian, and Mrs. Sohrab for their help in data gathering and cooperation throughout of my research work.

Lastly but not the least, I would like to express my great thank to my parents and brother for their encouragement and supports during my study period.

I certify that a Thesis Examination Committee has met on 1 March 2011 to conduct the final examination of Siavash Eghbali on his thesis entitled “Application of Geospatial Multiple Criteria Decision Analysis in Siting Combined Cycle Power Plant in Iran” in accordance with the Universities and University College Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The committee recommends that the student be awarded the Master of Science.

Member of the Examination Committee were as follows:

Ashurov Ravshan, PhD

Fellow Researcher
Institute of Advanced Technology
Universiti Putra Malaysia
(Chairman)

Saeid Pirasteh, PhD

Fellow Researcher
Institute of Advanced Technology
Universiti Putra Malaysia
(Internal Examiner)

Helmi Zulhaidi bin Mohd Shafri, PhD

Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Anuar Ahmad, PhD

Associate Professor
Faculty of Geoinformation Science and Engineering
Universiti Teknologi Malaysia
(External Examiner)

NORITAH OMAR, PhD

Associate Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 19 April 2011

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 Supervisory Committee were as follows:

Ahmad Rodzi Mahmud, PhD

Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Abdul Rashid Mohamed. Shariff, PhD

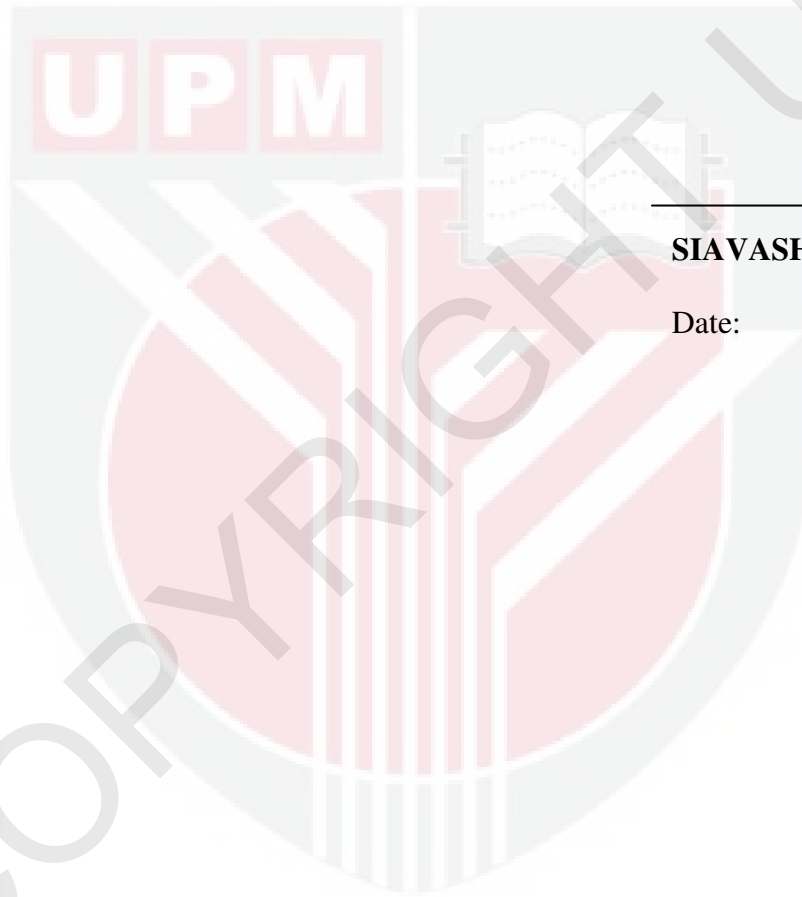
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

HASANAH MOHD GHAZALI, PhD

Dean and professor
School of Graduate Studies
University Putra Malaysia
Date:

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.



SIAVASH EGHBALI

Date:

TABLE OF CONTENTS

	Page
DEDICATION	ii
ABSTRACT	iii
ABSTRAK	v
ACKNOWLEDGEMENTS	vii
APPROVAL	ix
DECLARATION	x
LIST OF TABLES	xiv
LIST OF FIGURES	xvii
LIST OF ABBREVIATIONS	xxii
CHAPTER	
1 INTRODUCTION	1
1.1 Overview	1
1.2 Statement of the problem	2
1.3 Aim of study	4
1.4 Objectives	4
1.5 Scope of study	5
1.6 Thesis organization	6
2 LITERATURE REVIEW	8
2.1 Introduction	8
2.2 Scientific concept' definition, description, and relation	8
2.2.1 Power plant definition and types	9
2.2.2 Site suitability analysis, site suitability assessment, and site selection	15
2.2.3 Geographic Information System (GIS)	18
2.2.4 MCE & MCDA	22
2.3 Predecessor research revision	38
2.3.1 Researches in power plant site suitability analysis field	38
2.3.2 Research with comparative methodology	48
2.4 Conclusion	51
3 METHODOLOGY	52
3.1 Introduction	52
3.2 Site suitability assessment in 1:250,000 scale	54
3.2.1 Evaluation criteria and constraint determination	54
3.2.2 Preparation of criteria maps	66
3.2.3. Factor map reclassification	83

3.2.4	Developing hierarchical structure of evaluation criteria	85
3.2.5	Determining the relative importance of evaluation criteria using PWC	86
3.2.6	Layer integration using SAW	90
3.3	Site suitability assessment in 1:25,000 scale	92
3.3.1	Study area	93
3.3.2	Defining new scale criteria, data gathering, and factor map preparation	94
3.3.3	Determining of constraint and preparation of relative maps	107
3.3.4	Factor map reclassification	108
3.3.5	Establishment of new hierarchical structure	109
3.3.6	Defining of new scale study criteria weights	110
3.3.7	Layer integration using SAW	113
3.3.8	Bounding the final candidate sites	115
3.4	Site selection	116
3.4.1	Defining the site selection stages criteria hierarchy	116
3.4.2	Criteria values calculation of each alternative/ building the final criteria hierarchical structure	117
3.4.3	Defining the criteria weights using ratio estimation procedure	119
3.4.4	Determining the most suitable alternatives	121
3.4.5	Sensitivity analysis	122
4	RESULTS AND DISCUSSION	124
4.1	Introduction	124
4.2	Representation and interpretation of current research results	124
4.2.1	Result of 1:250,000 site suitability assessment	124
4.2.2	Result of 1:25,000 site suitability assessment	131
4.2.3	Site selection results	135
4.3	Comparison with related research	139
4.3.1	Comparison of applied criteria	139
4.3.2	Comparison of layer classifications and constraint zones	140
4.3.3	Comparison of weighting schemas	142
4.3.4	Comparison of final suitability value maps	143
5	CONCLUSION AND RECOMMENDATION	146
5.1	Introduction	146
5.2	Conclusion	147
5.2.1	1:250,000 site suitability assessment improvements	147
5.2.2	1:25,000 site suitability assessment improvements	149
5.2.3	Site selection findings	150
5.3	Recommendations	151
	REFERENCES	153

