

**PUBLIC HEALTHCARE FACILITY PLANNING IN MALAYSIA:
USING LOCATION ALLOCATION MODELS**

S.SARIFAH RADIAH BINTI SHARIFF

**INSTITUTE OF MATHEMATICAL SCIENCES
FACULTY OF SCIENCE
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KUALA LUMPUR**

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MALAYSIA: USING LOCATION ALLOCATION
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S.SARIFAH RADIAH BINTI SHARIFF

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**INSTITUTE OF MATHEMATICAL SCIENCES
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Name of Candidate: **S.Sarifah Radiah Binti Shariff**
I.C./Passport No.: **670601-10-6584**
Registration / Matric No.: **SHB070003**
Name of Degrees: **Doctor of Philosophy (PhD)**
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ABSTRACT

In many developing nations, the locations of public facilities are generally taken locally by government officers or by local elected leaders or by both. In Malaysia, the location of public health care are determined using some guidelines that were developed based on experience or some statistical information. There is still lack of formal analysis being carried out. As a result the decisions can very often be far from optimal. This study attempts to develop some mathematical location-allocation models for the locations of the public health care facilities in Malaysia. Two basic location allocation models with two different objectives are studied: The p -median problem and the Maximal Covering Location Problem (MCLP). We designed several solution methods by considering the un-capacitated, capacitated constraints and multiple objectives. The first part of the study focuses on the systems with un-capacitated facilities. The public healthcare facilities in Telok Panglima Garang(TPG), Selangor are taken as a case study to apply the models, and analyze the past and current location decisions. The models are extended to the capacitated case where a bigger district of Kuala Langat, Selangor is considered. These models which are in form of mixed integer programming models are solved using commercial optimization software CPLEX 10.2. The results from CPLEX are observed to violate some of facilities' constraint, thus making the solutions infeasible. A heuristic based on Genetic Algorithm (GA) is proposed and some computational analysis is carried out to gauge the performance of the existing facilities. In the third part of the study, a new model that simultaneously considers the p -median and the MCLP is proposed. The model is solved using a weighted sum multi objective approach that simultaneously minimizes

the average distance traveled (p -median) and maximizes the coverage percentage (MCLP). The data set are used to illustrate the effectiveness of the model. The fourth part concentrates on the development of a dynamic location model that incorporates a time factor. A sensitivity analysis which considers the future increase in demand and the need for new health care facilities is also carried out to assist the relevant authority to make proper planning of health care systems in Selangor and in Malaysia in general.

ABSTRAK

Di kebanyakan negara-negara membangun, lokasi kemudahan awam secara umumnya ditentukan oleh pegawai-pegawai kerajaan atau oleh pemimpin setempat yang dipilih atau kedua-duanya. Di Malaysia, lokasi penjagaan kesihatan awam ditentukan dengan menggunakan beberapa garis panduan yang telah dibangunkan berdasarkan pengalaman atau beberapa maklumat statistik. Terdapat masih kekurangan analisis formal yang dijalankan. Hasilnya keputusan selalunya boleh jauh dari optimum. Kajian ini cuba untuk membangunkan beberapa model matematik lokasi-peruntukan bagi lokasi penjagaan kemudahan kesihatan awam di Malaysia. Dua model asas peruntukan lokasi dengan dua objektif yang berbeza dikaji: Masalah p -median dan Masalah Lokasi Litupan Maksimal (MCLP). Kajian ini membentangkan beberapa kaedah penyelesaian model yang mempertimbangkan kekangan tidak had kapasiti bagi sesebuah kemudahan, berkapasiti dan berobjektif pelbagai. Bahagian pertama kajian ini memberi tumpuan kepada sistem dengan kemudahan tiada had kapasiti untuk kemudahan penjagaan kesihatan awam di Malaysia. Penjagaan kemudahan kesihatan awam di Telok Panglima Garang (TPG), Selangor telah diambil sebagai kajian kes untuk mengaplikasikan model bagi menganalisis keputusan lokasi di masa lalu dan semasa. Model-model itu diperluaskan kepada sekiranya kemudahan-kemudahan ini ada had kapasiti. Untuk tujuan ini, kawasan kajian yang lebih besar telah digunakan iaitu Daerah Kuala Langat, Selangor. Campuran model pengaturcaraan integer ini diselesaikan dengan menggunakan persisian komersial CPLEX 10,2. Hasil keputusan yang diperolehi dari CPLEX adalah didapati melanggar beberapa kekangan bagi kemudahan ini, sekali gus menjadikan penyelesaian infeasible. Heuristik yang

berdasarkan Algoritma Genetik (GA) adalah dicadangkan dan beberapa analisis pengiraan adalah dijalankan untuk mengukur prestasi kemudahan yang sedia ada. Dalam bahagian ke tiga kajian, satu model baru yang mempertimbangkan ke dua-dua objektif bagi model p -median dan MCLP pada masa yang sama adalah dicadangkan. Model ini diselesaikan dengan menggunakan sejumlah objektif wajar pendekatan pelbagai yang pada masa yang sama mengurangkan purata jarak perjalanan (p -median) dan memaksimumkan peratusan liputan (MCLP). Set data adalah digunakan untuk menggambarkan keberkesanan model. Bahagian keempat akan memberi tumpuan kepada pembangunan model lokasi dinamik yang menggabungkan faktor masa. Analisis sensitiviti yang mengambil kira peningkatan permintaan dan keperluan untuk kemudahan penjagaan kesihatan yang baru juga akan dilaksanakan untuk membantu pihak berkuasa yang berkaitan untuk membuat perancangan yang sesuai bagi sistem penjagaan kesihatan di Selangor dan di Malaysia secara amnya.

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TABLE OF CONTENTS

THESIS DECLARATION		Page
ABSTRACT		ii
ABSTRAK		iv
ACKNOWLEDGEMENT		vi
TABLE OF CONTENTS		vii
LIST OF TABLES		xi
LIST OF FIGURES		xiv
LIST OF ABBREVIATIONS		xvii
CHAPTER 1	INTRODUCTION	
1.1	Introduction	1
1.2	Problem Statement	3
1.3	Research Objectives and Scope	4
1.4	Research Contributions and Replicability	5
1.5	The Thesis Organisation	7
CHAPTER 2	LITERATURE REVIEW	
2.1	Introduction	10
2.2	Basic Facility Location Models	13
2.2.1	p -centre Model	15
2.2.2	p -median Model	17
2.2.3	The Set Covering Model and Maximal Covering Model	20
2.2.4	Hierarchical Location Allocation Models	23
2.3	Extended Location Models	27
2.4	Location Allocation Models for public healthcare facilities	31
2.4.1	The Solution Approaches	34

2.5	Summary and Conclusions	36
CHAPTER 3	HEALTH DELIVERY SYSTEM IN MALAYSIA	
3.1	Introduction	37
3.2	Types of Services provided by the public facilities	40
3.2.1	Public Facilities Administration	41
3.3	Government Policy and Location of health facilities	43
3.3.1	Comparison to other developing countries	47
3.4	Data Profile	50
3.4.1	Small Data Set – Mukim Telok Panglima Garang	50
3.4.2	Large Data Set – Kuala Langat	55
3.5	Summary and Conclusion	58
CHAPTER 4	UN-CAPACITATED MODELS	
4.1	Introduction	59
4.2	The p -median Problem	60
4.3	The Maximal Covering Location Problem (MCLP)	66
4.4	Model	71
4.5	Data Analysis (MTPG)	73
4.5.1	Locational Efficiency based on percentage of population coverage	76
4.5.2	Locational Efficiency based on average traveled distance	83
4.6	Conclusion	86
CHAPTER 5	THE CAPACITATED MAXIMAL COVERING LOCATION PROBLEM (CMCLP) PROBLEM	
5.1	Introduction	88
5.2	Capacitated MCLP (CMCLP)	90
5.2.1	Solution Methods from literature	91
5.3	Genetic Algorithm Based Heuristics	96
5.3.1	Genetic Algorithm Based Heuristics to solve related CMCLP	97
5.3.2	Genetic Algorithm for this study	99

5.4	Benchmarking Using Data from literature	106
5.5	Application of Genetic Algorithm on small study area	111
5.5.1	Locational Analysis using CMCLP	112
5.6	Extension of Application of Genetic Algorithm on large data set	116
5.6.1	Locational Analysis for Kuala Langat using MCLP and CMCLP	117
5.7	Conclusion	121
CHAPTER 6	THE CAPACITATED MODEL – CAPACITATED P-MEDIAN (CPMP)	
6.1	Introduction	123
6.2	Capacitated p -median (CPMP)	124
6.2.1	Literature Review of various solution methods	124
6.2.2	Genetic Algorithm Based Heuristic to solve CPMP	130
6.3	Implementation of Our Genetic Algorithm Based Heuristics (mCPMP)	132
6.3.1	Chromosome Representation	132
6.3.2	Computational Results	134
6.4	Locational Analysis using mCPMP	137
6.5	Relative Performance to CMCLP	141
6.5.1	Initial Study on data from literature (20 node network)	141
6.5.2	A Case Study of Kuala Langat using CPMP	142
6.6	Conclusions and Further Research	144
CHAPTER 7	EXTENDED MODELS	
7.1	Introduction	147
7.2	Multi-objective Model	148
7.2.1	The Mathematical Formulation of multi-objective model	152
7.2.2.	The Solution Method	154
7.2.3	Computational Results	155
7.2.4	Analysis of Weight	160

7.2.5	Conclusion and Direction for future research	163
7.3	Dynamic Model	163
7.3.1	Introduction to dynamic model	164
7.3.2	Dynamic Conditional Mathematical Formulation	167
7.3.3	A Case Study on district of Kuala Langat	170
7.3.3.1	Analysis on Existing Facilities	172
7.3.4	Analysis on projected volume	173
7.3.4.1	Selection of upgrading the existing facility and locating new facility	176
7.3.5	Results	181
7.3.6	Conclusions for dynamic modelling	190
7.4	Conclusions	191
CHAPTER 8	CONCLUSIONS AND FUTURE RESEARCH	
8.1	Introduction	193
8.2	Strengths and Advantages	193
8.2.1	Capacitated Maximal Covering Location Problem (CMCLP)	193
8.2.2	Capacitated p -median problem (CPMP)	194
8.3	Extended Models	195
8.3.1	Multi-objective model	195
8.3.2	Dynamic model	196
8.4	Conclusions	197
CHAPTER 9	CONCLUSIONS AND FUTURE RESEARCH	
9.1	Summary and Conclusions	198
9.2	Future Research	202
9.2.1	Hierarchy in public healthcare delivery system	202
9.2.2	Heuristics Algorithm	203
9.2.3	Others	204
REFERENCES		206
APPENDIX I	Distance Calculated for 179 nodes of Mukim Telok	219

APPENDIX II	List of ILOG CPLEX Code for the models used in the thesis	223
APPENDIX III	List of Communications with Ministry of Health (MOH) personnel	230
APPENDIX IV	List of MATLAB code for models used in the thesis	240
APPENDIX V	Data for details analysis of parameter values for a bi-objective model (Chapter 7)	251
APPENDIX VI	List of publications	253

LIST OF TABLES

Table	Title	Page Number
2.1	Hypothetical Hierarchical Healthcare System	24
3.1	Health facilities in Malaysia in 2006 (MOH Annual Report 2005)	38
3.2	Facilities provided by Ministry of Health, 2000 and 2005 (MOH Annual Report 2005)	39
3.3	Summary of types of services provided by Malaysian public facilities	41
3.4	Comparison of mortality indicators of selected nations (source: UNDP 2004)	47
3.5	Targets for consultations and health provision for Year 2007 (Telok Panglima Garang Health Clinics)	53
3.6	Targets for consultations and health provision for Year 2008 (Kuala Langat Health Clinics)	56
4.1	Demand Nodes Distribution	74
4.2	Coverage Percentage when demand nodes are uniformly distributed within service boundary only (S=5km)	77
4.3	Coverage Percentage when demand nodes are uniformly distributed within service boundary only (S=3km)	77
4.4	Coverage Percentage when demand is uniformly distributed over the whole study area (S=5km)	80
4.5	Coverage Percentage when demand is uniformly distributed over the whole study area (S=3km)	80
4.6	Comparing the Number of Demand Nodes and Volume Assignment to Each Facility (Demand is Uniformly Distributed within its Own Service Boundary)	82
4.7	Comparing the Number of Demand Nodes and Volume Assignment to Each Facility (Demand is Uniformly Distributed within the Whole Study Area)	83
4.8	Percentage of Improvement in Average Traveled Distance with the Increase of Number of Facilities when demand is uniformly distributed within the service boundary	84

LIST OF TABLES (continued)

Table	Title	Page Number
4.9	Percentage of Improvement in Average Traveled Distance with the Increase of Number of Facilities when demand is uniformly distributed within the whole study area	85
5.1	Profile for 3 sets of network	107
5.2	30 node network (Set I)	108
5.3	324 node network (Set II)	109
5.4	818 node network (Set III)	109
5.5	Comparison of CPLEX versus GA results for CMCLP based on GP (Case I)	113
5.6	Comparison of CPLEX versus GA results for CMCLP based on SP (Case I)	114
5.7	Comparison of CPLEX versus GA results for CMCLP based on PP (Case I)	114
5.8	Comparison of CPLEX versus GA results for CMCLP based on GP (Case II)	115
5.9	Comparison of CPLEX versus GA results for CMCLP based on SP (Case II)	116
5.10	Comparison of CPLEX versus GA results for CMCLP based on PP (Case II)	116
5.11	Result using GA based heuristic for MCLP (un-capacitated model)	118
5.12	Best Result using GA based heuristic	120
6.1	Comparison of GA based heuristic, Ghoseiri's and CGA on Set A	135
6.2	Comparison of GA based heuristic, CGA and <i>k</i> -means on Set B	136
6.3	Comparison of GA based heuristic and LSLSH on the SJC instances	136
6.4	Comparison of CPLEX 10.2 and GA results for mCPMP (based on GP)	138

LIST OF TABLES (continued)

Table	Title	Page Number
6.5	Comparison of CPLEX and GA results for mCPMP (based on SP)	139
6.6	Comparison of CPLEX and GA results for mCPMP (based on PP)	140
6.7	Result of 20 node network	142
6.8	Comparison between CMCLP versus mCPMP for Kuala Langat	143
7.1	Comparison of Typical Result between mGA, J_GA, Lagrangian Relaxation Heuristics (Haghani) and LINDO (based on objective function values)	158
7.2	Comparison of Typical Result between mGA, J_GA, Lagrangian Relaxation Heuristics and LINDO (based on facility locations)	159
7.3	Sample Result of a weighted bi-objective model when S=5km	160
7.4	Healthcare Profile of Kuala Langat showing the percentage of capacity usage (in 2007)	171
7.5	Population Growth Rate based on District Council Administration Area	174
7.6.1	Total Population Volume Forecast based on growth rate (first five years 2007-2012)	177
7.6.2	Total Population Volume Forecast Based on growth rate (second five years 2013-2017)	179
7.6.3	Total Population Volume Forecast Based on growth rate (third five years 2018-2022)	180
7.7	Details for the best result for upgrading facilities (first five years)	183
7.8	Profile of Potential New Locations	185
7.9	Details for the best result for upgrading and adding new facilities (second five years)	186
7.10	Details for the best result for upgrading and adding new facilities (third five years)	189

LIST OF FIGURES

Figure	Title	Page Number
2.1	Flow Chart of the Study	13
3.1	Hierarchy of public health care system in Malaysia	42
3.2	Structure of public facilities administration	45
3.3	Population distribution by age in Southeast Asia	49
3.4	Map of Selangor indicating all the districts	51
3.5	Map of Kuala Langat indicating Mukim Telok Panglima Garang	51
3.6	Map of Telok Panglima Garang indicating the service boundaries for all 5 rural clinics and the unpopulated regions	54
3.7	Map of Telok Panglima Garang indicating car roads and tracks together with the locations of 5 rural clinics	55
4.1	Distribution of two areas with different densities and their nodes distribution	75
4.2	Trend in Coverage Percentage (when demand is distributed uniformly over its own service area) when $S=5\text{km}$	78
4.3	Trend in Coverage Percentage (when demand is distributed uniformly over its own service area) when $S=3\text{km}$	78
4.4	Trend in Coverage Percentage (when demand is distributed uniformly over its own service area) when S varies	79
4.5	Trend in Coverage Percentage (when demand is distributed uniformly over the whole service area) when $S=5\text{km}$	81
4.6	Trend in Coverage Percentage (when demand is distributed uniformly over the whole service area) when $S=3\text{km}$	81
4.7	Trend in Coverage Percentage (when demand is distributed uniformly over the whole service area) when S varies	82
4.8	Trend in Average Traveled Distance when Demand is distributed uniformly within its own service boundary	86
4.9	Trend in Average Traveled Distance when Demand is distributed uniformly over the whole service area	86

LIST OF FIGURES (continued)

Figure	Title	Page Number
5.1	2-tiered System for public health care in Malaysia	89
5.2	An example of a chromosome where only two facilities A and D are open. Points 1,2,3,4 and 5 are the demand points	100
5.3	An example of a chromosome where only facilities B, C and E are open. Points 1,2,3,4, 5 10 are the demand points.	101
5.4	An example of uniform crossover operator when there are only 8 demand points	103
5.5	An example of order based crossover operator (OBX) when there are only 8 demand points	103
5.6	An example of insertion mutation when there are only 8 demand points	104
6.1	Trend of GA based heuristic and LSLSH on the SJC instances	137
6.2	Trend of CPLEX and GA results for CPMP (based on the three capacity sets, GP, SP and PP) when demand is distributed uniformly within its own service boundary	140
7.1	Trend of Objective Function Values for a bi-objective model (when S=5km)	161
7.2	Trend of Parameter Values for a bi-objective model (when S=5km)	163
7.3	Trend in Population Growth and Coverage Percentage (when S=3km)	175
7.4	Trend in Population Growth and Coverage Percentage (when S=5km)	175
7.5	District of Kuala Langat indicating the revised facility location	187

LIST OF ABBREVIATIONS

BA	Bionomic Algorithm
BHMM	Baldacci et al.
CC	Community Clinic
CCP	Capacitated Clustering Problem
CGA	Constructive Genetic Algorithm
CMCLP	Capacitated Maximal Covering Location Problem
CPkMP	Capacitated p -median with k existing facilities
CPMP	Capacitated p -median Problem
CPU	Computer Processing Unit
CS	Concentration Set
EMS	Emergency Medical Service
FNS	Fixed Neighbourhood Search
GA	Genetic Algorithm
GAP	Generalised Assignment Problem
GCSM	Guided Construction Search Meta-heuristic
GP	Government Policy
GRAMPS	Greedy Random Adaptive Memory Search Method
GRASP	Greedy Randomized Adaptive Search Procedure
GRIA	Global/Regional Interchange Algorithm
HC	Health Clinics
HCLP	Hierarchical Covering Location Problem
HFWC	Health and Family Welfare Centres

IDW	Inverse Distance Weighted
IMR	Infant Mortality Rate
ITH	Interchange Transfer Heuristic
J_GA	Jaramillo's Genetic Algorithm Representation
JKNS	Jabatan Kesihatan Negeri Selangor
KB	Kebun Bharu
KD	Klinik Desa
KK S	Klinik Kesihatan Sijangkang
KK TPG	Klinik Kesihatan Telok Panglima Garang
KK	Klinik Kesihatan
KLIA	Kuala Lumpur International Airport
KM	Kampung Medan
LAH	Location Allocation Heuristic
LP	Linear Programming
L-S	Lagrangean-Surrogate
LSCP	Location Set Covering Problem
LSLSH	Local Search Heuristic
MB	Mulvey & Beck
MCLP	Maximal Covering Location Problem
MCP	Maximal Covering Problem
mCPMP	Modified Capacitated p -median Problem
mGA	Modified Genetic Algorithm
MOE	Ministry of Education Malaysia
MOH	Ministry of Health Malaysia
MOLIP	Multi-Objective Linear Integer Programming
MTPG	Mukim Telok Panglima Garang

NHA	National Health Account
NHP	National Health Policy
NISE	Non Inferior Set Estimation
NP	Non Polynomial
OC	Osman & Christofides
OC-GA	Opportunity Cost Genetic Algorithm
OPL	Optimization Programming Language
OR	Operation Research
PCLS	Periodic Construction Local Search
PHC	Primary Healthcare
PP	Proposed Policy
RBK	Rumah Bidan Kerajaan
RC	Rural Clinics
SA	Simulated Annealing
SD	Sijangkang Dalam
SIC	Staff In Charge
SJC	San Jose Campus-city
SL	Sijangkang Luar
SP	Staff Perception
SQM	Stochastic Queue Median
SSCPLP	Single Source Capacitated Plant Location Problem
SS-PR	Scatter Search using Path Relinking
SS-V	Scatter Search by Voting
TPG	Telok Panglima Garang
TS	Tabu Search
UFLP	Un-capacitated Facility Location Problem

UK	United Kingdom
USA	United States of America
VNS	Variable Neighborhood Search
WHO	World Health Organization
WPRO	WHO Regional Office