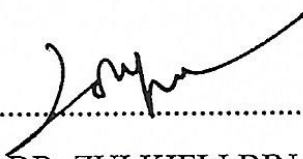


**FLOOD DAMAGE AND RISK ASSESSMENT FOR URBAN AREA IN
SEGAMAT**

NOOR SURAYA BINTI ROMALI

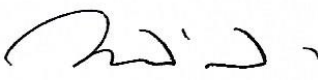
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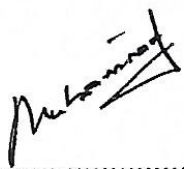
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SEGAMAT

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A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy (Civil Engineering)

School of Civil Engineering
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August 2018

I declare that this thesis entitled “*Flood Damage and Risk Assessment for Urban Area in Segamat*” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date : 9/8/2018

DEDICATION

To my beloved parents
Romali Bin Jusoh and Fatimah Binti Mohamad

To my pillar of strength
Aimi Ilmar Bin Ramli

To the love of my life
Muhammad Aiman Bin Aimi Ilmar
Noor Aina Sofia Binti Aimi Ilmar

To me
Thank you for not giving up!

ACKNOWLEDGEMENT

In the name of Allah, the most Gracious, the most Merciful,

First and foremost, I would like to express my sincere appreciation to my supervisor, Prof. Dr. Zulkifli Yusop for his guidance and wisdom. Thank you for the continuous encouragement and support throughout this PhD journey. My endless gratitude also goes to Dr. Zulhilmi Ismail, Dr. Muhammad Sulaiman and Ahmad Zuhdi Ismail for without them, I'd be lost in searching for guidance and ideas.

I would also like to convey my utmost gratitude to the Ministry of Higher Education (MOHE) and Universiti Malaysia Pahang for the scholarship that made it possible for me to sustain my studies. This study has been supported by research grant Q.J130000.2409.00G08, R.J130000.7809.4F208 and Institut Inovasi Strategik Johor (IISJ) Vot 15H00.

Special kind of love and gratitude to all my family members; especially my husband, my children, my parents, my parents in law and my siblings for all the patience and tolerance, for they are the backbones that have supported me throughout this journey and without them, the journey to my PhD won't be possible. To my friends and colleagues, I thank you for all the help and motivation and most importantly being so understanding in these testing years.

Last but not least, to my sweethearts, Aiman and Aina. Thank you for always pushing me to do my best. Please forgive me for all the times I had missed out, for the lack of attention or if I had hurt you both unintentionally for not being there. Do remember that for all that I have done, it is solely for both of you.

ABSTRACT

In recent years, risk-based flood mitigation approach received more attention compared to conventional or structural approach. However, in developing countries, literatures on flood vulnerability assessment are limited especially on flood damage. In Malaysia, the assessment of flood damages is challenging due to data scarcity. Hence, an attempt has been made to establish a flood damage assessment framework for an urban area of Segamat town, Johor. The concept of flood risk involved the elements of hazard, exposure, and vulnerability. The combination of hydrological characteristics, exposed elements, value of exposed elements, and flood damage function curve was used for estimation of flood damages. The flood depth and areal extent were obtained from flood modeling and mapping using HEC-HMS/RAS and Arc GIS. A site-specific flood depth–damage curve was developed based on land use category, socio-economic status of the flood victims and property characteristics. Due to data scarcity, synthetic method was applied to generate flood damage data based on the 2011 major flood event. Damage percentage was calculated by dividing the replacement cost by the market value of the properties and plotted against the observed flood depth. In addition to flood depth, the flood damage was also influenced by household income and property's price. Therefore, the residential category was further divided into three sub-categories; low price house (LPH), medium price house (MPH) and high price house (HPH). Using R^2 of 0.76 for commercial area and from 0.80 to 0.85 for various residential categories, the flood depth–damage curves obtained in this study were good enough and comparable with other studies. The estimated total damages for residential and commercial categories during the 2011 flood were RM456 mil and RM143 mil respectively. The expected annual damage (EAD) for residential areas (50,112 units) and commercial areas (9,318 premises) were RM12.59 million and RM2.96 million respectively. Generalized Pareto (GP) distribution model was used to estimate peak discharge of 10, 25, 50, 100, 200, 500 and 1000 ARI which were subsequently applied for deriving flood maps. Based on the GP distribution, the 2011 flood was equivalent to 42 years average recurrence interval (ARI). Flood hazard map shows that Bandar Seberang area (46,184 properties) was the most affected by flood. The flood damage risk map illustrates similar patterns where the distribution of damages were concentrates at the Bandar Seberang area with some properties suffered damages of more than RM15,000 per unit. Although it is a site-specific study, the framework can be applied to assess the potential future damages and serve as a basis for future studies on flood risk assessment in Malaysia.

ABSTRAK

Kebelakangan ini, pendekatan tebatan banjir berasaskan risiko menerima lebih banyak perhatian berbanding pendekatan konvensional yang menggunakan pendekatan struktur. Walau bagaimanapun, di negara-negara membangun, literatur berkaitan penilaian risiko banjir dari segi kesan kepada masyarakat dan harta benda adalah terhad terutama berkaitan penilaian kerosakan banjir. Di Malaysia, penilaian kerosakan banjir sukar dilakukan kerana kekangan data. Oleh itu, kajian ini bertujuan untuk menghasilkan satu rangka kerja penilaian kerosakan banjir untuk kawasan bandar Segamat, Johor. Konsep risiko banjir merangkumi unsur ancaman, pendedahan dan kerentanan akibat banjir. Gabungan ciri-ciri hidrologi, unsur terdedah, nilai unsur terdedah, nilai anggaran kerosakan disebabkan banjir dan lengkung fungsi kerosakan banjir digunakan bagi menganggarkan kerosakan banjir. Maklumat aras banjir dan kawasan litupan banjir diperolehi daripada permodelan dan pemetaan banjir menggunakan HEC-HMS/RAS dan Arc GIS. Lengkung kedalaman-kerosakan banjir yang khusus untuk kawasan kajian telah dihasilkan berdasarkan kategori guna tanah, status sosio-ekonomi mangsa banjir dan ciri-ciri harta benda. Disebabkan kekurangan data, kaedah sintetik digunakan untuk menghasilkan data kerosakan banjir berdasarkan peristiwa banjir besar 2011. Peratusan kerosakan (dikira dengan membahagikan kos baik pulih dengan nilai pasaran hartanah) di plot melawan kedalaman banjir. Selain daripada kedalaman banjir, tahap kerosakan banjir adalah dipengaruhi oleh pendapatan isi rumah dan harga kediaman. Oleh itu, kerosakan bagi kategori kediaman dibahagikan kepada tiga sub-kategori iaitu rumah harga rendah (LPH), rumah harga sederhana (MPH) dan rumah harga tinggi (HPH). Dengan R^2 0.76 untuk kategori komersil dan 0.80 hingga 0.85 bagi pelbagai kategori penempatan, lengkung kerosakan banjir yang diperolehi adalah baik dan setara dengan kajian-kajian lepas. Anggaran jumlah kerosakan kategori kediaman dan komersil akibat banjir tahun 2011 adalah RM456 juta dan RM143 juta. Jangkaan kerugian tahunan (EAD) untuk kawasan kediaman (50,112 unit) dan kawasan komersil (9,318 premis) adalah RM12.59 juta dan RM2.96 juta. Model taburan Generalized Pareto (GP) telah digunakan untuk menganggar aliran puncak bagi 10, 25, 50, 100, 200, 500 and 1000 ARI, yang seterusnya digunakan bagi menghasilkan peta ancaman banjir. Berdasarkan model taburan GP, banjir 2011 bersamaan dengan 42 tahun purata selang pengulangan (ARI). Peta ancaman banjir menunjukkan bahawa kawasan Bandar Seberang (46,184 harta) adalah yang paling terjejas semasa banjir 2011. Peta risiko kerosakan banjir menggambarkan pola taburan kerosakan yang sama di mana taburan kerosakan tertumpu di Bandar Seberang dengan sebahagian asset mengalami kerosakan lebih daripada RM15,000 per unit. Walaupun fokus kajian ini hanya terhad kepada kawasan kajian, rangka kerja ini dapat digunakan bagi menilai potensi kerugian pada masa akan datang dan boleh dijadikan asas untuk kajian penilaian risiko banjir di Malaysia pada masa-masa akan datang.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	AUTHOR DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENTS	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	xi
	LIST OF FIGURES	xiv
	LIST OF ABBREVIATIONS	xviii
	LIST OF SYMBOLS	xx
	LIST OF APPENDIX	xxi
1	INTRODUCTION	1
	1.1 Flood Risk Management as a Flood Mitigation Measure	1
	1.2 Problem Statement	3
	1.3 Objectives of the Study	5
	1.4 Scopes and Limitations of the Study	6
	1.5 Significance of Study	7
	1.6 Structure of the Thesis	8
2	LITERATURE REVIEW	9
	2.1 Introduction	9
	2.2 The Concepts of Flood Risk and Damage Assessment	12
	2.2.1 Flood Risk Assessment	12

2.2.2	Flood Damage Assessment	13
2.3	Flood Damage Assessment Framework	19
2.3.1	Classification of Flood Damages	19
2.3.2	Flood Damage Estimates	21
2.3.2.1	Hydrological Characteristics (Flood hazard)	23
2.3.2.2	Characteristics and Values of Exposed Elements	26
2.3.2.3	Flood Damage Function	27
2.3.3	Validation of Flood Damage Assessment	27
2.3.3.1	Uncertainty and Sensitivity Analysis	29
2.4	Framework of Flood Damage Function Curve	31
2.4.1	Flood Depth-Damage Curve Approaches	31
2.4.2	Flood Damage Data Collection	36
2.4.3	Synthetic Flood Depth-Damage Curve	40
2.4.4	Flood Damage Influencing Factors	42
2.4.5	Determination of Damages Percentages	45
2.5	Expected Annual Damage (EAD), Flood Damage-Probability Curve and Flood Damage Risk Mapping	46
2.6	Summary	47
3	RESEARCH METHODOLOGY	49
3.1	General Methodology	49
3.2	Description of Study Area	52
3.3	Development of Flood Damage Function Curve	54
3.3.1	Data Collection and Preparation	56
3.3.1.1	Questionnaire Survey	57
3.3.1.2	Pilot Study	58
3.3.2	Synthetic Flood Damage Data	60
3.3.3	Construction of Flood Damage Function Curve	61
3.3.3.1	Selection of Flood Parameters	61
3.3.3.2	Percentage of Damage	62
3.4	Flood Modeling	63

3.4.1	Flood Frequency Analysis	64
3.4.1.1	Finding the Best Flood Distribution Model	65
3.4.1.2	Quantile Estimation of Generalized Pareto in ARI	66
3.4.2	Hydrological Modelling	70
3.4.2.1	Hydrological Model Set Up (HEC-HMS)	70
3.4.2.2	Model Calibration and Validation	72
3.4.2.3	Model Efficiency	74
3.4.3	Hydraulic Modelling	75
3.4.3.1	Hydraulic model set up (HEC-RAS)	75
3.4.3.2	Floodplain Modeling Using HEC-GeoRAS	78
3.5	Flood Damage and Risk Assessment	80
3.5.1	Flood Damage Estimation	80
3.5.2	Validation of Flood Damage Assessment	81
3.5.2.1	Uncertainty and Sensitivity Analysis	81
3.5.3	Flood Risk Assessment	83
4	FLOOD DEPTH - DAMAGE CURVE	84
4.1	Generation of Synthetic Flood Damage Data	84
4.1.1	Socio-economic and Property Characteristics of Segamat town	85
4.1.2	Characteristics of Damage Dataset	88
4.1.3	Relationship between Socio-Economic, Property Characteristics and Flood Damage	94
4.2	Development of Flood Depth-Damage Curve	101
4.2.1	Relationship between Flood Depth and Damage Percentage	102
4.3	Flood Depth-Damage Curve Comparison	108
4.3.1	Comparison with Other Depth-Damage Curve	108
4.3.2	Segamat Curve vs. Moschato Curve	110
4.4	Conclusion	112

5	FLOOD DAMAGE AND RISK ASSESSMENT	113
5.1	Flood Modeling and Mapping	113
5.1.1	Flood Distribution Model	113
5.1.2	Hydrologic Modeling	121
5.1.2.1	Model Calibration	123
5.1.2.2	Model Validation	124
5.1.2.3	2011 Flood Event	125
5.1.3	Water Level Simulation of 2011 Flood and Various ARI	126
5.1.4	Flood Mapping of 2011 Flood Event and Various ARI	130
5.1.5	Comparison of Flood Mapping and Flood Mark Verification	135
5.2	Flood Damage Assessment	138
5.2.1	Damage Estimates of 2011 Segamat Flood Event	139
5.2.2	Damage Estimates of Various ARIs	140
5.3	Risk Assessment	143
5.3.1	Expected Annual Damage (EAD) and Flood Damage–Probability Curve	144
5.3.2	Flood Damage Risk Mapping	144
5.3.2.1	Residential	145
5.3.2.2	Commercial	150
5.4	Validation of Flood Damage Estimates	155
6	CONCLUSIONS AND RECOMMENDATIONS	158
6.1	Conclusions	158
6.2	Recommendations for Future Research	162
	REFERENCES	164
	APPENDIX	175

LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	Summary of adopted approaches and elements considered in the assessment of flood damages	15
2.2	Examples of different types of flood damages (adapted from Dutta et al., 2003; Merz et al., 2010)	20
2.3	Classes of flood damages (adapted from Merz et al. (2010) and Pistrika et al. (2014)	20
2.4	Selected flood damage estimation equations	22
2.5	Uncertainty components adopted in flood damage studies	30
2.6	Summary of flood damage function approach	32
2.7	Summary of data collected in the survey questionnaire form used by KTA Tenaga Sdn. Bhd. (2003)	39
2.8	Classification of damage influencing factors from various literatures	44
3.1	Input data required for stage-damage function curve	56
3.2	Questionnaire survey outline for residential and commercial category	57
3.3	Survey area for flood damage data collection at Segamat town	59
3.4	Parameter estimation methods applied in this study	66
3.5	Rainfall stations used for hydrological modeling	71
3.6	Element parameter and method setup in HEC-HMS model	72

3.7	The variation of uncertainty component used in this study	82
4.1	Background of the respondents for residential category	85
4.2	Sample size by educational background and occupation	86
4.3	Distribution of residential respondents by household income	86
4.4	Property characteristics of residential category	87
4.5	Property characteristics of commercial category	88
4.6	Statistical characteristics of residential damage dataset per building storeys, building type, and building materials	89
4.7	Statistical characteristics of residential damage dataset per building storeys, business types, and building materials	90
4.8	Summary of regression analysis on variables that influence the structural and content flood damages for residential and commercial category	95
4.9	Average flood depth and flood duration	95
4.10	White test for heteroscedasticity results	98
4.11	Regression analysis on impact of socio-economic and property variables on structural flood damages for commercial category	98
4.12	Regression analysis on impact of socio-economic and property variables on content flood damages for commercial category	98
4.13	Robust standard errors result for commercial structure	99
4.14	Robust standard errors result for commercial content	99
4.15	Comparison of damage percentages of Segamat and Moschato Curve for residential and commercial categories	111
5.1	Fitting results for probability distribution of annual flood	115
5.2	Goodness-of-fit test ranking result	115

5.3	Peak flow for various return period using General Pareto distribution model	121
5.4	The result of the observed and simulated peak flow	121
5.5	Tested model parameters for 2011Segamat Flood Event	122
5.6	Model efficiency statistical calculation for calibrated model	124
5.7	Model efficiency statistical calculation for validated model	125
5.8	Comparison of simulated maximum flood depth from the present study and NAHRIM (2012)	137
5.9	Simulated and observed flood depth during the November 2011 flood	138
5.10	Estimated damages for residential and commercial categories during the 2011 flood	139
5.11	Estimates of flood damages for residential category for various ARIs	141
5.12	Estimated of flood damages for commercial category for various ARIs	141
5.13	Estimates of flood damages for residential LPH, MPH, and HPH sub-categories for various ARIs	142
5.14	Expected Annual Damage (EAD) for Residential and Commercial Category	144
5.15	Sensitivity Factor and Damage Estimates (RM) using Variations of Damage Estimation Components	156

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
2.1	Flood depth-damage curve for residential structural (wooden) category (Dutta et al., 2003)	35
2.2	Flood depth-damage curve for industrial category (Penning-Rowsell and Chatterton, 1979)	35
3.1	Flow chart of overall research methodology	51
3.2	Location of Segamat river	52
3.3	Location of the study area: Segamat town	53
3.4	Land use of Segamat town	54
3.5	Flow chart of the development of flood damage function curve	55
3.6	DEM of Segamat town	64
3.7	Flow chart for flood frequency and deriving the ARI	65
3.8	Flow chart of hydrological modeling methodology	70
3.9	Hydrological modelling set up for at Segamat River Basin	71
3.10	The (a) simple canopy, (b) simple surface, (c) SMA, (d) Clark Transform, and (e) Muskingum routing parameters used in the hydrological model development	74
3.11	Flow chart of hydraulic modeling procedure	75
3.12	Location of flood marks for 2011 flood event at Segamat town	76
3.13	(a) DID flood mark and (b) flood mark shown by flood victim	77
3.14	HEC-RAS geometry model setup at Segamat River	77

3.15	Example of cross section editor in HEC RAS	78
3.16	The framework of flood modelling in HEC-GeoRAS (UN-SPIDER Knowledge Portal, 2014)	79
4.1	(a) Low, (b) medium, and (c) high price house of concrete type houses in Segamat town	93
4.2	Example of terrace house at (a) Taman Sri Pelangi and (b) Taman Pelangi, Segamat	94
4.3	The relationship between residential structural damage (in percentages) with household income (monthly)	96
4.4	Residual plot for damage variable for category: (a) residential structure (b) residential content (c) commercial structure and (d) commercial content	101
4.5	Residential flood depth-damage curve for categories; (a) low price house, (b) medium price house and (c) high price house	104
4.6	Residential flood depth-damage curve (content)	104
4.7	Comparison of curves for all residential categories	105
4.8	Commercial flood depth-damage function curve (structure)	105
4.9	Commercial flood depth-damage function curve (content)	106
4.10	Comparison of curves for commercial categories	106
4.11	Comparison of residential and commercial curves	107
4.12	Comparison of residential depth-damage curve with Segamat curve	109
5.1	The annual peak flow at Sg. Segamat gauging station from 1960 to 2011	115
5.2	(a) Probability density function (b) Cumulative distribution function (c) P-P plots and (d) probability difference plotted on Log-Normal (3P), Weibull (3P), General Extreme Value, Log-Pearson 3, and General Pareto distributions	120

5.3	Conceptual of the hydrological model at Sg. Segamat River Basin	123
5.4	Observed and calibrated hydrograph for 26th May – 7th June 2010 data	124
5.5	Observed and validated hydrograph for 4th Aug. to 9th Sept. 2010 data	125
5.6	Hydrograph for 2011 Segamat flood event	126
5.7	Cross section (water level) of Segamat River	127
5.8	Cross section profile at (a) Point 1 (Sg. Kapeh), (b) Point 2 (Segamat River) and (c) Point 3 (Segamat River 2)	128
5.9	Water surface elevations profile at Point 2 (Segamat River) and Point 3 (Segamat River 2) for 2011 flood event	129
5.10	Water surface elevations at Point 2 (Segamat River) and Point 3 (Segamat River 2) for various return periods	130
5.11	Flood mapping of Segamat 2011 flood event	131
5.12	Simulated inundated area for (a) 10 (b) 25 (c) 50 (d) 100 (e) 200 (f) 500 and (g) 1000 ARI flood	132
5.13	Flood inundated area of Segamat 2011 flood: (a) present study in comparison with (b) the study by (NAHRIM, 2012)	136
5.14	1:1 line for observed and simulated flood depth for 2011 Segamat flood	137
5.15	Flood damage-probability curve for residential category	143
5.16	Flood damage-probability curve for commercial category	144
5.17	Flood damage risk map of 2011 Segamat flood for Residential category	146
5.18	Residential flood damage risk map for ARIs of (a) 10 (b) 25 (c) 50 (d) 100 (e) 200 (f) 500 and (g) 1000 years ARI	146
5.19	Flood damage risk map of 2011 Segamat flood for Commercial category	150

5.20	Flood damage risk map for commercial category for ARIs of (a) 10 (b) 25 (c) 50 (d) 100 (e) 200 (f) 500 and (g) 1000 years ARI	151
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LIST OF ABBREVIATIONS

AM	-	Annual Maximum
ARI	-	Average Recurrence Interval
CBA	-	Cost Benefit Analysis
Cum.	-	Cumulative
DID	-	Drainage and Irrigation Department
DEM	-	Digital Elevation Model
DF	-	Damage factor
EAD	-	Expected Annual Damage
e.g.	-	Example given
EM-DAT	-	Emergency Disasters Database
FB	-	Food and Beverage
FDAP	-	Flood Damage Analysis Package
FHAM	-	Flood Hazard Assessment Model
GEV	-	Generalized Extreme Value
GIS	-	Geographic Information System
GOF	-	Goodness of Fit
GP	-	Generalized Pareto
GS	-	Good and Services
GUI	-	Graphical User Interface
HEC-HMS	-	Hydrologic Engineering Center's Hydraulic Modeling System
HEC-RAS	-	Hydrologic Engineering Center's River Analysis System
HPH	-	High Price House

ICPR	- International Commission for the Protection of the River Rhine
IPF	- Iterative Proportional Fitting
ISFAR	- Interferometric Synthetic Aperture Radar
K-S	- Kolmogorov-Smirnov
KTA	- Kumarasivam, Tan & Ariffin
LOOCV	- Leave-One-Out Cross-Validation
LPH	- Low Price House
MAE	- Mean Absolute Error
MAR	Missing at Random
MBE	- Mean Bias Error
MCAR	- Missing Completely at Random
ME	- Model Efficiency
Mil.	- Million
MNAR	- Missing Not at Random
MPH	- Medium Price House
MRE	- Minimum relative error
MURL	- Ministerium für Umwelt, Raumordnung und Landwirtschaft des Landes Nordrhein-Westfalen
NAHRIM	- National Hydraulic Research Institute of Malaysia
OFAT	- One Factor at a Time
PD	- Partial Duration
POT	- Peaks Over Threshold
RM	- Ringgit Malaysia
RMSE	- Root Mean Square Error
Sg.	- Sungai (river)
TIN	- Triangular Model Network
TS	- Time Series
USACE	- The United States Army Corps of Engineers

LIST OF SYMBOLS

Σ	Summation of
%	Percentages
X_T	T-year quantile
k	Shape parameters
α	Shape parameters
σ	Continuous scale parameters
β	Continuous scale parameters
μ	Continuous location parameters
γ	Continuous location parameters
Q	Flow
R^2	Coefficient of determination
$<$	Less than
\geq	Greater than or equal to
$>$	Greater than
m^3/s	Cubic metres per second
mm/hr	Millimetre per hour
hr	Hour
m	Metre

LIST OF APPENDIX

APPENDIX	TITLE	PAGE
A1	Questionnaire Survey Form for Residential Category	175
A2	Questionnaire Survey Form for Commercial Category	181
B	Regression Result	186
C	Annual Maximum Flow (Q) from 1960 to 2011 Used for Frequency Analysis	189
D	Flood Marks	190
E1	Unit Values (Residential)	195
E2	Unit Values (Commercial)	196
F	Calculation of Expected Annual Damage (EAD)	197

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