

List of Contents

Disclaimer	i
Abstract	ii
Acknowledgement	iii
List of Contents	iv
List of Figures	vi
List of Tables	vii
List of Appendices	viii
List of Abbreviation	ix
 1. Introduction	 1
1.1. Background	1
1.2. Research Problem	4
1.3. Research Objective	5
1.4. Specific Objectives and Research Questions	5
1.5. Research Benefit	6
1.6. Structure of the Thesis	6
 2. Literature Review	 7
2.1. Wildfire Hazards	7
2.2. Wildfire Process	8
2.3. Wildfire Factors	8
2.4. Wildfire Causes	10
2.5. Wildfire Events in Mountainous Area	10
2.6. Emergency Response	11
2.7. Evacuation Planning	11
2.8. GIS Network Analysis	12
2.9. Least-Cost Path Analysis	14
2.10. Multi Criteria Evaluation	15
2.11. Multi Criteria Decision Analysis	16
2.12. Analytical Hierarchy Process	16
 3. Study Area	 17
3.1. Location	17
3.2. Climate	15
3.3. Geology	16
3.4. Topography	16
3.5. Land Cover	17
3.6. Social and Economic Condition	17
3.7. Accessibility to the National Park	19
3.8. Tourism Activity in the National Park	19

4.	Research Methods	24
4.1.	Materials	24
4.1.1	Imageries and Maps	24
4.1.2	Software	24
4.2.	Research Methods	25
4.2.1	Land Cover Classification from Landsat 8 2015	26
4.2.2	Slope Classification from TerraSAR-X DEM 2011	26
4.2.3	Historical Wildfire Location	27
4.2.4	Identification of Wildfire Prone Areas	27
4.2.5	Distance from Path Analysis	28
4.2.6	Network Analysis	28
4.2.7	Least-Cost Path Analysis	29
4.2.8	Multi Criteria Evaluation	31
4.2.8.1	The Criteria for Suitable Area in Emergency Activity	33
4.2.8.2	The Criteria for Suitable Area in Evacuation Activity	34
4.2.9	Multi Criteria Decision Analysis	35
5.	Results and Discussions	37
5.1.	Historical Wildfire Occurrences	37
5.2.	Land Cover Classification	40
5.3.	Slope Classification	42
5.4.	Distance from Path	44
5.5.	Wildfire Prone Area	45
5.6.	Network Analysis – Existing Route in GMNP	47
5.7.	Characteristics of Route in GMNP	48
5.8.	The New, Alternative Access and Evacuation Route in GMNP	52
5.9.	The New Alternative Access Routes based on LCP Analysis	53
5.10.	Characteristic of the Alternative Routes	55
5.11.	Least-Cost Path vs Existing Routes	57
5.12.	Suitable Area for Emergency Activity	59
5.13.	Suitable Area for Evacuation Activity	60
5.14.	The Most Suitable Alternative Route of Emergency and Evacuation	61
5.15.	The Most Suitable Existing Route of Emergency and Evacuation	63
5.16.	The Most Optimum Route in Case of Emergency Activity	64
5.17.	The Most Optimum Route in Case of Evacuation Activity	66
5.18.	Final Recommendation for Emergency and Evacuation Planning	68
6.	Conclusions	69
6.1	Conclusions	69
6.2	Recommendations	71
	References	72
	Appendices	77

List of Figures

2-1	Fundamental Triangle of Fire	8
2-2	External Factor Systems for Wildfire Function	9
2-3	Internal Factor Systems for Wildfire Function	9
3-1	Map of Gunung Merbabu National Park	17
3-2	Villages Surrounding Gunung Merbabu National Park	18
3-3	Principal livelihood of 13 villages's communities in District of Boyolali	21
4-1	Methodological Flowchart of the Research	25
4-2	Workflow analysis for finding the LCP given to descriptive feature classes ..	29
4-3	The Process of Multi Criteria Decision Analysis	35
5-1	Map of the Area where Wildfires Occurred in GMNP	38
5-2	Land Cover Map of Gunung Merbabu National Park 2015	40
5-3	Slope Map of Gunung Merbabu National Park	42
5-4	Distance from Hiking Path Gunung Merbabu National Park	44
5-5	Wildfire Prone Area of Gunung Merbabu National Park	45
5-6	The Existing Routes in GMNP	47
5-7	The Topographic Profile of Existing Routes in GMNP	50
5-8	Four Alternative Access Routes into GMNP Resulting from LCP Analysis ..	53
5-9	Topographic Profiles of the New Alternative Routes in GMNP	55
5-10	Least-Cost Path and the Existing Routes of GMNP	57
5-11	Map of Suitable Area for Emergency Activity	59
5-12	Map of Suitable Area for Evacuation Activity	61
5-13	The Most Optimum Route for Emergency based on Existing Routes	64
5-14	The Most Optimum Route for Emergency based on LCP's Alternatives	65
5-15	The Most Optimum Route for Evacuation based on Existing Routes	66
5-16	The Most Optimum Route for Evacuation based on LCP's Alternatives	66
5-17	Final Recommendation for Emergency and Evacuation Planning in GMNP..	68

List of Tables

2-1	Various Studies that Using Least-Cost Path Analysis	14
2-2	Various Studies that Using AHP for Multi Criteria Evaluation	15
2-3	Scale for Pairwise Comparison (Saaty, 1977)	16
3-1	The Number of Visitors of Gunung Merbabu National Park	23
3-2	The number of visitors through Selo between Mt Merapi and Mt Merbabu	23
4-1	Maps and Image that has been used in this study	24
4-2	Weight Distribution in Least-Cost Path Analysis	30
4-3	Sum Weight Rank in determining the Most Suitable Route	33
4-4	The Rank of Routes in terms of Distance, Emergency and Evacuation Suitability	36
5-1	Wildfire Occurrences in Gunung Merbabu National Park 2011 – 2015	37
5-2	The Area and Percentage of Land Cover in Gunung Merbabu National Park	40
5-3	The Area and Percentage of Slope Classification in GMNP	43
5-4	Calculation of Wildfire Prone Area in Gunung Merbabu National Park	46
5-5	Characteristics of Routes in Gunung Merbabu National Park	48
5-6	Route Characteristics based on the Location and Access from Several Cities	51
5-7	Comparison between Existing Routes and Alternative Routes in GMNP	58
5-8	The Most Suitable Alternative Route in Case of Emergency and Evacuation	62
5-9	The Most Suitable Existing Route in Case of Emergency and Evacuation	63

List of Appendices

1	Map of water source point in GMNP	77
2	Map of facilities in GMNP	77
3	Each criteria for emergency activity and result of weighted overlay raster map	78
4	Each criteria for evacuation activity and result of weighted overlay raster map	79
5	Example of rank alternative preferences in the context of distance	80
6	Example of rank alternative preferences in the context of route suitability	80
7	Example of weight distribution between distance and route suitability	80

List of Abbreviations

AHP	: Analytical Hierarchy Process
BPBD	: Badan Penanggulangan Bencana Daerah (Regional Disaster Management Agency)
BPS	: Badan Pusat Statistik (Central Bureau of Statistics)
BIG	: Badan Informasi Geospasial (Geospatial Information Agency)
DEM	: Digital Elevation Model
FAO	: Food and Agriculture Organization
GIS	: Geographic Information System
GMNP	: Gunung Merbabu National Park
GPS	: Global Positioning System
LCP	: Least Cost Path
m. a. s. l	: Meter Above Sea Level
MCDA	: Multi Criteria Decision Analysis
MCE	: Multi Criteria Evaluation
MOF	: Ministry of Forestry
MPA	: Masyarakat Peduli Api (Fire Care Community)
Mt	: Mountain
PERHUTANI	: Perusahaan Hutan Negara Indonesia (Indonesian State Forestry Enterprise)
PHKA	: Perlindungan Hutan dan Konservasi Alam (Forest Protection and Nature Conservation)
RS	: Remote Sensing
SNI	: Standar Nasional Indonesia (Indonesian National Standard)
SPTN	: Satuan Pengelolaan Taman Nasional (National Park Management Unit)
USGS	: United States Geological Survey