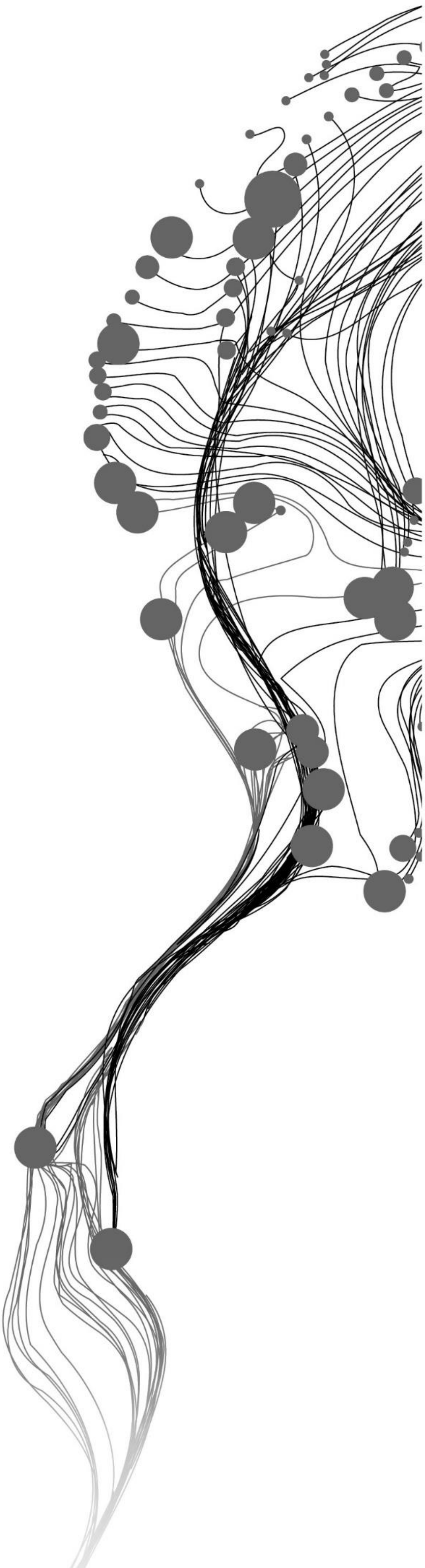
PLANNING OF URBAN GREEN SPACES AS EVACUATION AREA IN EARTHQUAKE DISASTER

GENTRIA ARDIPUTRI PARAMITA
7 December, 2015

SUPERVISORS:
ITC Supervisor Dr. R.V. Sliuzas
ITB Supervisor Dr. Ir. Denny Zulkaidi, MUP



PLANNING OF URBAN GREEN SPACES AS EVACUATION AREA IN EARTHQUAKE DISASTER

GENTRIA ARDIPUTRI PARAMITA
Enschede, The Netherlands, December 2015

Thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente in partial fulfilment of the requirements for the degree of Master of Science in Geo-information Science and Earth Observation.
Specialization: Urban Planning and Management

SUPERVISORS:
ITC Supervisor Dr. R.V. Sliuzas
ITB Supervisor Dr. Ir. Denny Zulkaidi, MUP

THESIS ASSESSMENT BOARD:
Prof.dr.ir. M.F.A.M. van Maarseveen (Chair)
Drs. N.C. Kingma (External Examiner, University of Twente)

ABSTRACT

After an earthquake there is a need to evacuate the refugee into evacuation area. Urban green spaces may be suitable for this purpose.The aim of this study is to assessing suitability of urban green spaces as evacuation area. The function of urban green space not also ecological but also disaster prevention and reduction function as evacuation area and this study tries to combine it.

The main object of this study is to develop a GIS-based approach to assess the suitability urban green spaces for use as evacuation areas in the event of earthquake disaster. This research used one approach in advance land use suitability analysis the Multi Criteria Decision Analysis (MDCA). Multi Criteria Analysis is a tool that create for complex multi criteria problem that add qualitative and/or quantitative aspects of the problem in decision making process. To spatially implement multi criteria analysis it used Spatial Multi Criteria Evaluation (SMCE) module of Integrated Land and Water Information System (ILWIS) and to determine the weight values between criteria, the Analytic Hierarchy Process (AHP) was adopted.

Bandung serve as case study because based on earthquake risk assessment from RADIUS project the earthquake may lead to a variety of severe damage that can illustrated with Modified Mercalli Intensity (MMI) scale 8 to 9. There is 6 suitability factor used in this study distance from building, distance from road network, capacity of accommodation, slope, earthquake intensity zone. Moreover, from the AHP result the highest weight for suitability factor is distance from building 23,4 % followed by earthquake intensity zone 23,1 %, capacity of accomodation 16,2 %, slope 14,5 %, distance from water network 13,4 % and distance from road network 9,4 %.

This research found that urban parks as one alternative for evacuation area. Urban parks is suitable to used as evacuation area because has characters of a large quantity, wide distribution and easy accessible. Urban parks can't afford all of estimation refugees, only 27 % from the total estimation refugees. It is need additional area for accommodated all of the refugee. Public facilities such as schools, hospitals, and stadiums are generally suitable for use as a shelters.

The location and proportions of urban green spaces is not evenly distributed within the city. There is a need to plan appropriate proportions and distribution of urban parks to make evacuation area can established by relying on existing urban parks

Keyword: urban green spaces, urban parks, evacuation area, SMCE, AHP.

ACKNOWLEDGEMENTS

Bismillahirrahmanirrahim, all praise to Allah swt, the Most Gracious and the Most Merciful was granted ability to complete my research project in ITC.

First of all, would like to express my sincere gratitude to my supervisors: Dr. R.V. Sliuzas and Dr. Ir. Denny Zulkaidi, MUP for guiding me during the work of my thesis with their invaluable guidance, comments and supports that I am now able to complete my research. I would like to thank you for Prof.dr.ir. M.F.A.M. van Maarseveen, as chairman examiner and Drs. N.C. Kingma, as external examiner.

I would like to thank you for NESO Indonesia for funding me for study in ITC and BAPPENAS for funding me to study in ITB. Thank you so much for the opportunity.

I would give special thank to all my Indonesian friends for the friendship and togetherness and also special thanks to Ratna Sari Dewi for the valuable correction.

Finally, I dedicate this hard work, patience, and endurance to my parents, my husband and my beloved son.

Enschede, December 2015

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1. INTRODUCTION

1.1. Background and Justification

Indonesia has a unique position as an earthquake prone country. It is the place of interaction for three tectonic plates, namely the Indo-Australian, Eurasian and Pacific plates. Annually, approximately ten percent of the annual world's earthquakes occur in Indonesia. Bandung, the third largest city in Indonesian after Jakarta and Surabaya, is located in Zone III of the Indonesian seismic zones(see Figure 1.1), representing medium hazard (Surahman, 2000) is also affected by earthquakes. The Lembang fault, an active fault located about 20 km north of Bandung, is well known. Several other faults are also around the Bandung area. The area is tectonically unstable and has a high potential for earthquakes although it is not as severe as the Zone I or II on the seismic zoning.

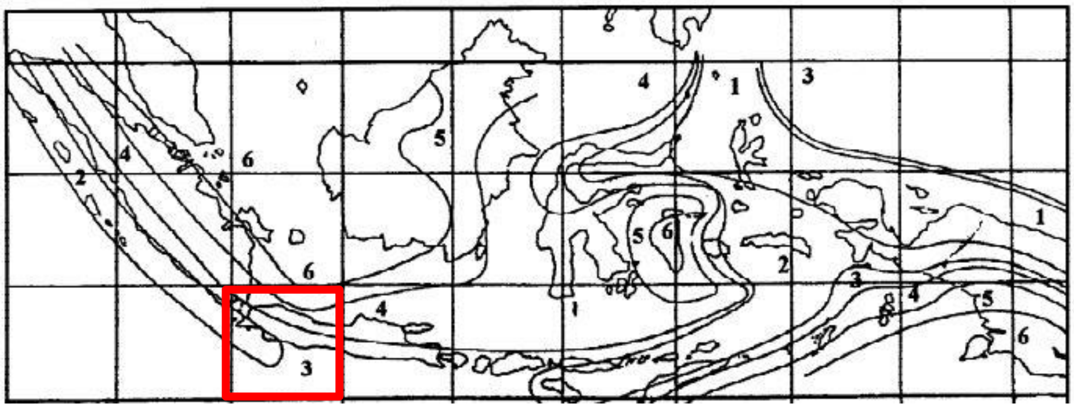

Figure 1.1 Indonesia Seismic Zone

Source: (Merati, Surahman, & Sidi, 1996)

Bandung is considered as one of the most vulnerable city, due to its population density and soil condition, shown by the alluvial formation from the ancient lake bed sediment which covers a large part of the Bandung plateau. Bandung municipality's population is about 2,5 million inhabitants (Central Bureau Statistic of Indonesia, 2014)while that of the Greater Bandung Area is about 4 millions.

The analysis of seismic hazards and risks in Bandung municipality used the Risk Assessment Tools for Diagnosis of Urban Areas Against Seismic Disaster (RADIUS), it is the latest comprehensive study concerning earthquake disaster assessment in Bandung (UN IDNDR, 2000). RADIUS is integrated with a GIS software and used for risk assessment, scenario modelling, vulnerability studies and microzonation of cities. RADIUS project is organized by the United Nations Office for the Coordination of Humanitarian Affairs as part of their activities in the International Decade for Natural Disaster Reduction (UN IDNDR).

The risk assessment process consists of identifying seismic hazard at city level, through the determination of peak ground acceleration (PGA) which might occur in Bandung, presented as PGA contour, and assessment of secondary hazard such as landslide prone areas. The vulnerability of the city was assessed based on its socio-economic condition and demographic situation, its building stocks, specific vulnerable areas such as dense dwelling areas, emergency response structure etc. The use of an earthquake damage

scenario introduced by the RADIUS project provides more understanding of the risk level of the city, as it develops estimates on loss of property (buildings) and loss of life's, including the damage level of various infrastructure, in case of an earthquake occurrence.
Seismic Hazard Assessment considers the local geotechnical conditions and result in a seismic microzonation map, a spatial distribution of PGA in ground level. Seismic microzonation map was developed by 200 years return periode . Seismic microzonation map is shown in Figure 1.2.

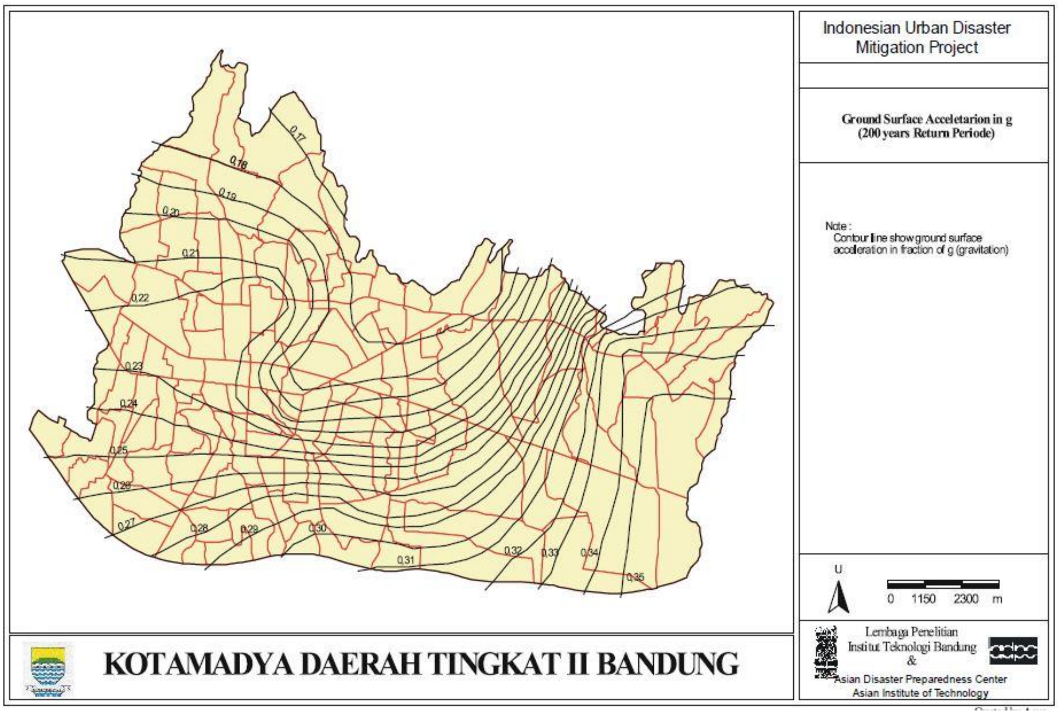

Figure 1.2 Seismic Microzonation Map

Source: (UN IDNDR, 2000)

It is seen that the magnitude of the PGA in the South Bandung is greater than in the North. Moreover, the risk analysis results show that the earthquake may lead to a variety of severe damage that can illustrated with Modified Mercalli Intensity (MMI) scale 8 to 9(UN IDNDR, 2000). MMI scale is used to quantified seismic intensity which has numerical values ranging from I (detected only by seismic instruments) to XII (causing total destruction of most buildings).

From the risk assessment, an earthquake of this magnitude also caused damages to the buildings it can be seen from the table 1.1 below.

Table 1.1 Building Damage Estimates in Bandung based on Radius Project

District	p.g.a (g)	Number of Building	Damaged Building	Damaged Building (%)
Andir	0.23	20324	12348	60.8
Antapani	0.22	16360	9917	60.6
Arcamanik	0.29	5936	5050	85.1
Astana Anyar	0.26	12791	10682	83.5
Babakan Ciparay	0.26	15908	13043	82.0
Bandung Kidul	0.3	5135	4168	81.2
Bandung Kulon	0.25	16007	13399	83.7
Bandung Wetan	0.2	6035	3093	51.3
Batununggal	0.22	20978	13193	62.9
Bojongloa Kaler	0.25	16389	14301	87.3
Bojongloa Kidul	0.28	10480	8546	81.6
Buah Batu	0.3	13486	10354	76.8
Cibeunying Kaler	0.17	13846	4666	33.7
Cibeunying Kidul	0.17	17963	6122	34.1
Cibiru	0.35	6420	5353	83.4
Cicendo	0.22	14128	8756	62.0
Cidadap	0.18	8214	4620	56.3
Cinambo	0.34	10143	8685	85.6
Coblong	0.2	17768	11793	66.4
Gedebage	0.34	8235	7007	85.1
Kiara Condong	0.22	14882	9301	62.5
Lengkong	0.25	10460	8515	81.4
Mandalajati	0.29	5936	5050	85.1
Panyileukan	0.35	6420	5353	83.4
Rancasari	0.34	8235	7007	85.1
Regol	0.26	12592	10121	80.4
Sukajadi	0.21	15486	9107	58.8
Sukasari	0.19	11104	7117	64.1
Sumur Bandung	0.2	6907	3994	57.8
Ujung Berung	0.34	10143	8685	85.6

Source: (UN IDNDR, 2000)

According to the RADIUS project (2000) after an earthquake many areas may be isolated due to collapsed buildings and blocked roads. Therefore, it is important to prepare suitable locations for evacuation areas as safe locations for residents after a disaster. Such evacuation areas are temporary but safe location after a disaster.(Elheishy, Saleh, & Asem, 2013). Urban green spaces may be suitable for this purpose.

Urban green spaces refer to the open green spaces located in urban districts, for leisure and outdoor entertainment of citizens. They have multiple function such as public welfare, recreational, entertainment functions for daily use of citizens. These amenities also play a part in regulating climate, conserving water, purifying the air, and protecting biodiversity. Due to the disaster events of recent years, the urban green space has served the function of sanctuary (Li, Liu, & Jiao, 2002).

In the 1923 Great Kanto Earthquake, the 1976 Tangshan Earthquake and the 2008 Wenchuan Earthquake millions of refugees were evacuated to public green spaces in cities(Ye & Fu, 2013). Urban parks can be categorized as open safe area (Naghdi, Mansourian, Valadanzoej, & Saadatseresht, 2008). They may also be an optimal shelter location for citizens in case of emergencies (Ye & Fu, 2013). This functionality in particular is attracting more attention to these spaces.

1.2. Research Problem

Based on "Ministerial Regulation of Public Works No. 05/PRT/M/2008" concerning Guidelines for Provisioning and Utilization Green Open Space in Urban Areas (Government of Indonesia, 2008) stated that function and application of green space in urban areas is different depending on the urban area typology. In disaster situations, urban green space function may change as a disaster evacuation area.

Urban green spaces in Bandung are about 11.4 % of the city area (Government of Bandung Municipality, 2011b) and nowadays serve as recreational and entertainment. Meanwhile, urban green spaces also have function as evacuation area as stated in Bandung Spatial Plan 2011-2031. By Law. Bandung government have a policy for the prone disaster area by the development of urban park, sports courts, and other public open spaces into a points or shelters for evacuation. However, as not all green spaces may be suitable to serve as evacuation area due to their size, location or other characteristics, there is a need to develop a suitable method to assess the suitability of urban green spaces as evacuation areas.

1.3. Research Objective

1.3.1. Main objective

The main objective of this research is to develop a GIS-based approach to assess the suitability of urban green spaces for use as evacuation areas in the event of earthquake disaster. This study will use the city of Bandung as a case study

1.3.2. Specific objective

1. To identify the requirements for evacuation areas
2. To describe the characteristics of existing urban green spaces
3. To develop a method for assessing urban green space suitability as evacuation areas
4. To evaluate the method on the basis of the Bandung case

1.4. Research Questions

To realize the above stated objectives, the following research questions shall be answered:

1. To identify the requirements for evacuation areas
   - What criteria should an evacuation area satisfy?
   - How much space per refugee is required?

2. To describe the characteristics of existing urban green spaces
   - How are the existing of the urban green spaces classified?
   - Where are the candidate site of urban green spaces located?

3. To develop a method for assessing urban green space suitability as evacuation areas
   - What are the criteria that can be used for assessing the urban green spaces?
   - How to standardize and weight criteria for assessing urban green spaces?

4. To evaluate the method on the basis of the Bandung case
   - Can the method identify appropriate urban green spaces used as evacuation area in Bandung case?
   - What interventions are necessary to make unsuitable areas is suitable?

1.5. Research Limitation

There are several limitations in this research which can be summarized as follows:

- Limitation of data collection

This research used the earthquake risk assessment from in year 2000 from RADIUS Project the outcomes of the analysis cannot be evaluated as they are based upon outdated data, hence this study will critically discusses the methodology of the study.

- Limitation of approach

The criteria used are selected based on available data from the government agencies and RADIUS Project.

- Limitation of data processing

The spatial and non spatial data from government agencies used in this study may include some uncertainties and that might affect the validation of the model.

1.6. Conceptual Framework

This research tries to combine the functions of urban green space not only ecological functions but also disaster prevention and reduction functions by assessing the suitability of urban green spaces as evacuation area. The conceptual framework of this research integrates 3 aspects. Site demand is based on number and location of refugees, site requirements is based on minimum size of temporary shelter is 2000 M^2 and criteria for selected temporary shelter (distance from building, distance from road network, capacity accommodation, earthquake intensity zone , slope and distance from water network and candidate of urban green spaces is used urban parks because has characters of a large quantity, wide distribution and easy accessible. (Figure 1.3).Geospatial data required for the study will be processed in GIS environment and for assessing urban green space suitability will used Multi Criteria Analysis. To spatially implement multi criteria analysis it used Spatial Multi Criteria Evaluation (SMCE) module of Integrated Land and Water Information System (ILWIS).

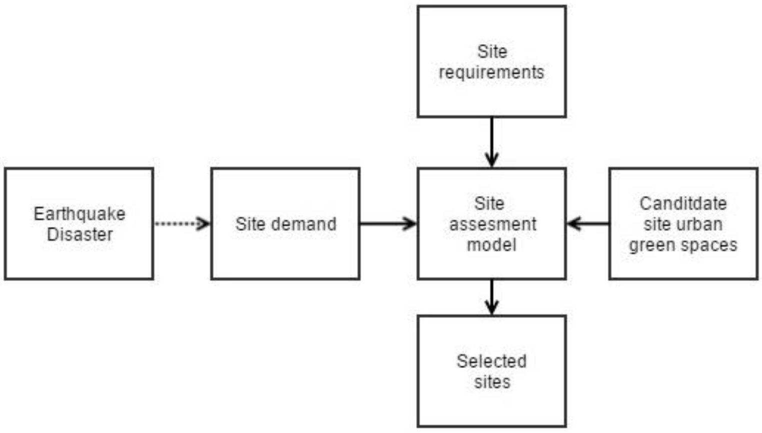

Figure 1.3 Conceptual Framework

1.6 Structure of the thesis

Chapter 1. Introduction : This chapter presents a general overview of the research problem, background and justification. It also presents the research problem, objectives and questions.
Chapter 2. Literature Review : This chapter present general description about urban green space, urban parks as evacuation area, earthquake risk assessment by RADIUS in Bandung City, evacuation area, urban green spaces suitability analysis, spatial multi criteria evaluation and analytic hierarchy process.
Chapter 3: Research Methodology: The focus in this chapter will be on research design, the lists of spatial and non spatial data, method and tools to assessing the suitability of urban green spaces for evacuation area
Chapter 4: Results and Discussion: This chapter presents the results produced by applied methods (chapter 3). The results and assessment of the method will explained and discussed.
Chapter 5: Conclusion and Recommendation: This chapter explain conclusions based on result and discussion and also give recommendation for future study.

2. LITERATURE REVIEW

In this chapter literature are explained. First the general description about urban green space and function of urban park as evacuation area. Second, explained about the earthquake risk assessment in Bandung City and requirement of evacuation area. Lastly, explain GIS based approach for assessing the suitability of urban green spaces using spatial multi criteria evaluation and analytic hierarchy process.

2.1. Urban Green Spaces

Urban green space is a generic term for public and private space that are naturally or artificially endowed with vegetation within the administrative boundaries of a town or city (Haq, 2011). Urban green space is an essential element of urban quality of life. The rising concern in environmental quality has cause rising attention to integration of urban green space in urban fabric. In history several scholar have tried to integrate them for example : landmark of green movement by Ebenezer Howard's that proposed 'Garden City' the formulation of a city with a planned presence of green area (Baycan-Levent, Vreeker, & Nijkamp, 2009), Charles Fourier's fantasy villages called 'phalansteries' and Ernest Callebach's novel *Ecotopia* (van Leeuwen, Nijkamp, & de Noronha Vaz, 2010)

Urban green space present a range of benefit in various form. They increase the character of cities by contribute positively to the quality of life and balance the impact of the negative result of human activities. Moreover, they design the basis for the conservation of fauna and flora; contribute to the preservation of a healthy urban environment; and the local natural & cultural heritage (van Leeuwen et al., 2010).

In Indonesia based on Spatial Planning Law No 26 year 2007 concerning Spatial Planning (Government of Indonesia, 2007), Green Open Space (*Ruang Terbuka Hijau / RTH*) is define as a lengthwise, stripe or agglomerated area with a characteristics of open utilization, publicly or privately owned, act as a place to grow plants naturally. Moreover, based on the Ministerial Regulation of Public Works No. 05/PRT/M/2008 about Guidelines for the Provisioning and Utilization Green Open Space in Urban Areas the green open space can be divided into four aspects physical (natural and artificial), functional (ecology, aesthetic, socio-cultural & economy), structural (ecological pattern &planned pattern) and ownership (public and private). Urban green space can grouped in four board type house and office yard, urban park & forest, green ways and green space for specific function.

Private green space although restricted for groups of people, sometimes can have public functions, for example, for landscape or environmental characteristics. Public green areas not only serve as ornamental green-space (historic gardens, urban parks, road side, neighborhood green-spaces, conservation and urban forest) but also functional green-space represented by green-space for sports, education, health and/or recreational purposes (Fratini & Marone, 2011).
Another function of urban green spaces is provide a shelter when disaster happen. In the Hanshin-Awaji Big Earthquake Japan in 1995 small parks and open spaces in dense urban areas played critical roles in

prevent the spread of fires and became the immediate refuges for the refugee (Ishikawa, 2002). Public urban green spaces should be preferred as these can be managed easier that private urban green space (FEMA, 2007). A playground or a park is best suited for shelter since their existing type of use does not restrict the camp development (The SPHERE Project, 2011). In Indonesia based on Ministerial Regulation of Public Works No. 05/PRT/M/2008 type and function of urban green spaces can be described with the Table 2.1 below.

Table 2.1 Type, function and ownership of urban green spaces

Type	Function	Ownership
1.Home garden	Absorb pollution and also place for ornamental plants and productive plants (fruits, vegetables, and flowers).	Private
2.Office court yard	Open parking area, carport, and a place to organize a variety of outdoor activities such as ceremonies, fairs, sports, and others.	Private
3. Neighborhood park	Neighborhood park consists of 4 park it is local park (*Taman RT/RW*), sub-district park (*Taman kelurahan*) and district park (*Taman kecamatan*).	Private/Public
4. City park	City park is a green space (green field), which is equipped with leisure facilities, playground (kids / toddlers), and elderly facilities . All the facilities are open to the public	Public
5. Urban forest	Conservation area, buffering area (preservation, protection and utilization of genetic resources, biodiversity) and various social activities of the community nature, tourism, and recreation.	Public
6. Green belts	Buffer zone or border between the two cities.	Public
7. Road side green spaces	Forming the architecture of the city, water conservation area, and also used for beauty / aesthetics of the city.	Private/Public
8. Train lines	Security against the railway traffic to maintain the safety of rail traffic and the surrounding community.	Public
9. Electrical transmission network green space	An electrical transmission network safety.	Public
10. River basin	Conservation and prevention to erosion in riverbanks area.	Public
11. Coastal area green space	Conservation area against sea waves.	Public
12. Springs water green spaces	Protection, preservation, enhancement function of raw water sources / springs, and control the destructive force of water sources / springs / lake through monitoring activities.	Public
13. Cemetery	Public place for burial people, beautification of the city, water catchment areas, protective and ecosystem support.	Public
14. Roof garden	In the limited area, urban green space can utsed non green open space area such as rooftops, terrace house etc. by using additional media such as pots	Private
15.Space below flyover	Water catchment, and hide structure of street that are not attractive	Public

Source: Ministerial Regulation of Public Works No. 05/PRT/M/2008

From the Table 2.1 above it can be seen that not all type of urban green spaces can be used as evacuation area due to their existing function, urban parks is suitable to be used as evacuation area. From this regulation also divided the urban parks hierarchy into city and neighborhood parks (local park (*Taman RT/RW*), sub-district park (*Taman kelurahan*) and district park (*Taman kecamatan*)). Park can be owned both by private and public. However, in this study only parks owned by public will be researched.

2.2 Function of urban parks as evacuation area

Urban parks contribute a range of benefits in developing ecological environment and diversification of the urban landscape. Additionally, they also have a benefit as disaster prevention and reduction for example prevent fire from spreading, prevent flood from overflowing and provide emergency shelter from a disaster (Fan et al., 2012).

Public facilities such as schools, hospitals, and stadiums use as primary evacuation area in Western countries and in Japan, but in Wenchuan earthquake in China, such facilities have breakdown and fail (Liu et al., 2011). Another public facilities like urban green spaces become important due their possible function as emergency shelter. It has characters of a large quantity, wide distribution and easy accessible (Fan et al., 2012).

Large-sized urban park in sub urban area serve as long term shelter because of their possible of large area. Medium-sized urban park and urban forest serve as short term shelters. Small-sized urban parks and neighborhood park close to residential districts can serve as immediate shelter, the three types of shelters can broaden their roles; for instance, an urban green space for long term shelter can also be used for immediate shelter and short term shelter if needed (Fan et al., 2012). This study tries to combine the function of urban green space not also ecological functions but also disaster prevention and reduction function.

Document response to earthquake from around the world suggest that open or green space surrounding building have critical role both during and after earthquake event (Allan & Bryant, 2010) for example Kanto region of Japan experienced a major earthquake in September 1923 and it is also affected Tokyo. From this situation the role of parks in disaster prevention began to bring attention because green spaces such as Ueno Park is proved effectively to prevent the spread of fire. (Hao, 2011).Moreover, in the post-disaster reconstruction planning of Tokyo, the first disaster prevention park planning in Japan was build with a large number of small parks and safe areas were settled in residential areas. This area is attached by wide streets and parks and have a function as general recreation area/playground but could also used as shelter in the case of disaster (Hao, 2011) see Figure 2.1 (a).

One example of public disaster-prevention green spaces in Tokyo is The Tokyo Rinkai Disaster Prevention Park (Ministry of Land Infrastructure Transport and Tourism Japan, 2015). This park providing area total 13.2 ha and equipped with Wide Area Disaster Prevention Base (disaster prevention facility managed by the Cabinet Office), Learning Facilities (a "public park facility" that is managed by the Ministry of Land, Infrastructure, Transport and Tourism.), Entrance space (area used for medical care support in a time of disaster, rescue operations effectively done and various equipment's or facilities provided for triage), Multi-purpose plaza (basecamp site where emergency response units for lifesaving or restoration and incoming volunteers work in a time of disaster) and Heliport see Figure 2.1 (b)

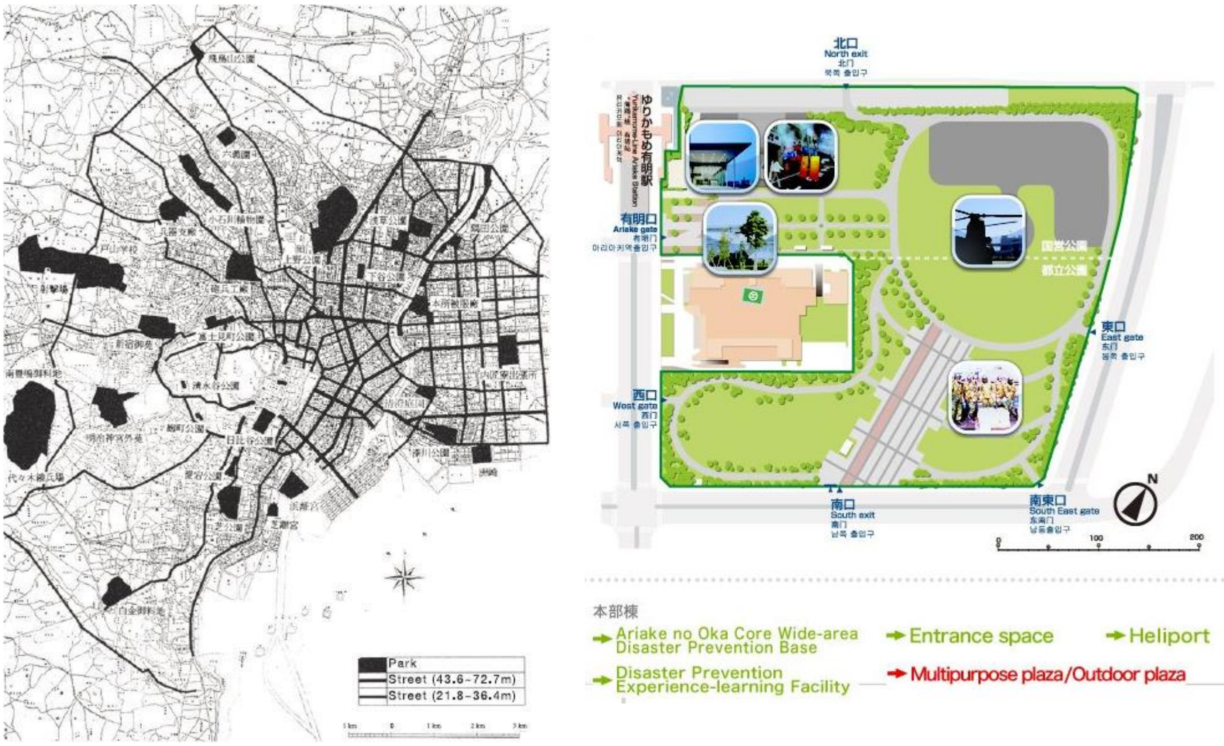

Figure 2.1 (a).The post disaster reconstruction planning of Tokyo (b). Map of Tokyo Rinkai Disaster-Prevention Park

(a) source: (Ishikawa, 2002) (b) source: (Ministry of Land Infrastructure Transport and Tourism Japan, 2015)

2.3 Earthquake risk assesment by RADIUS (Risk Assessment Tools for Diagnostic of Urban Areas against Seismic Disasters) in Bandung City

To improve city awareness toward earthquake risk, UN IDNDR implemented the project called Risk Assessment Tools for Diagnosis of Urban Areas Against Seismic Disasters (RADIUS) during 2000 year and in Indonesia taking Bandung as its pilot study area. The project was carried out collectively by Research Center for Disaster Mitigation ITB, Urban and Regional Planning ITB and Institute Research and Community Service ITB. Moreover for implementation it is involved many participants from Bandung Government, Research & Development Center of Housing and Settlements and Research & Development Center of Geology(ADPC, 2000)

The RADIUS project was established a computer program for simplified Earthquake Damage Estimation. The program required input data for example population, building types, ground types, and lifeline facilities. Outputs was seismic intensity (MMI), building damage, lifeline damage and casualties, which are shown with tables and maps (Guragain, Jimee, & Dixit, 2008)

The risk assessment process consisted of identifying seismic hazard at city level, through the determination of peak ground acceleration which might occur in Bandung, presented as PGA contour as seen in Figure 1.2(UN IDNDR, 2000) .The region with the highest intensity was district Cibiru and Panyileukan and the lowest intensity area was districts Cibeunying Kaler and Cibeunying Kidul. The risk analysis resulted also showed that the earthquake might lead to a variety of severe damage that could be illustrated with Modified Mercalli Intensity (MMI) scale 8 to 9

(earthquake intensity zone 1 to 6) see Figure 2.2 .The highest earthquake intensity 9 is located in south of city (zone 6) meanwhile intensity 8 (zone 1) is located in the north of the city.

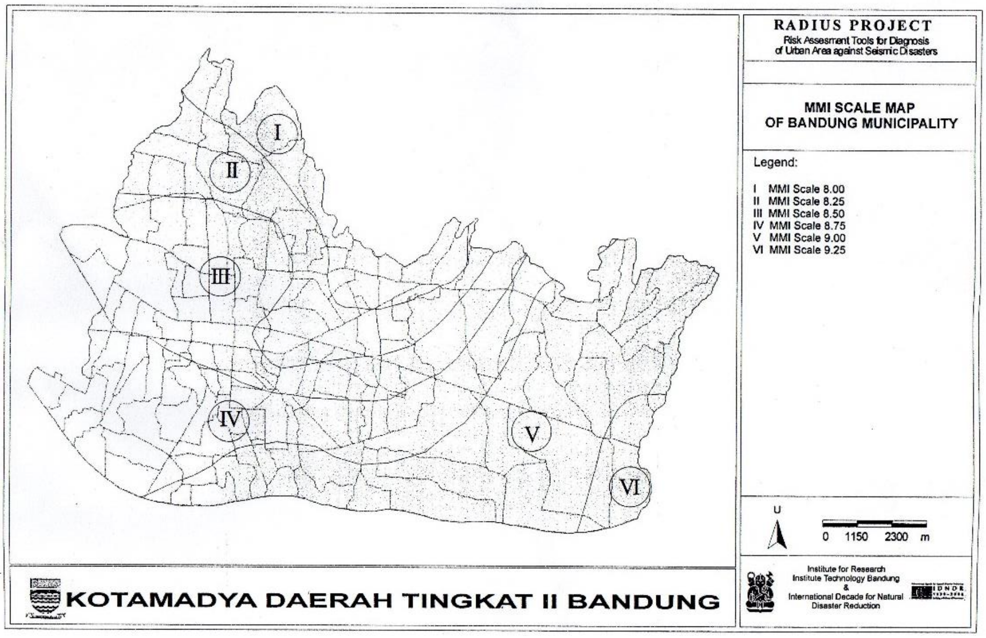

Figure 2.2 Earthquake Intensity Zone in MMI Scale

Source: (UN IDNDR, 2000)

Moreover, for assessment of secondary hazard it seen that Bandung have landslide vulnerable area located in the north area of Bandung (UN IDNDR, 2000) (see Figure 2.3)

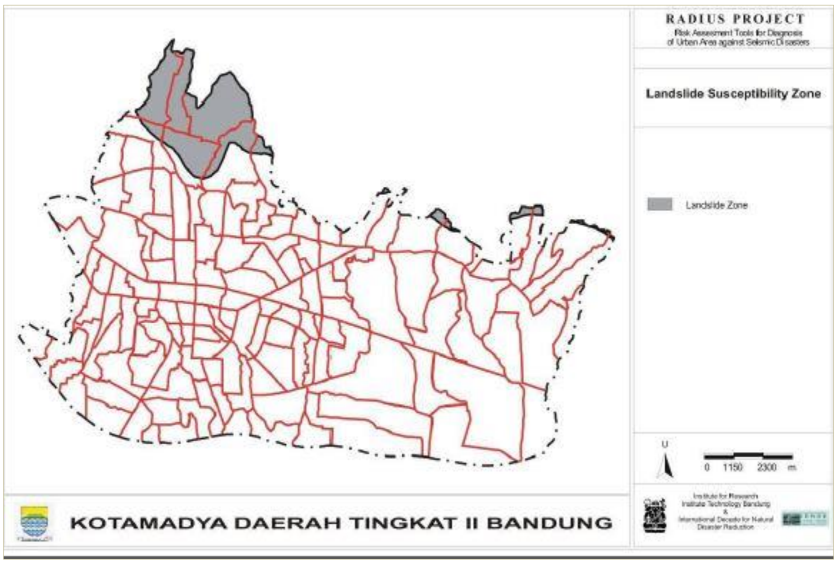

Figure 2.3 Landslide Susceptibility Zone

Source: (UN IDNDR, 2000)

The damage level of various infrastructure can be explain below: The highest building damage located in Bojongloa Kaler district (Surahman, 2000). The railway, electricity networks, and clean water sources will be severely damaged. Highest water network damaged is located in Gedebage and Ujungberung district.

Moreover, Cibeunying district, which has the densest traffic, will experience the worst road damage. In the Tegallega, Cibeunying, and Bojonegera district, bridge damage will also be grave (UN IDNDR, 2000) (for details see Figure 2.4). The use of an earthquake damage scenario introduced by the RADIUS project bring more understanding of the risk level of the city, as it develops estimates on damage building and damage level of various infrastructure, in case of an earthquake occurrence

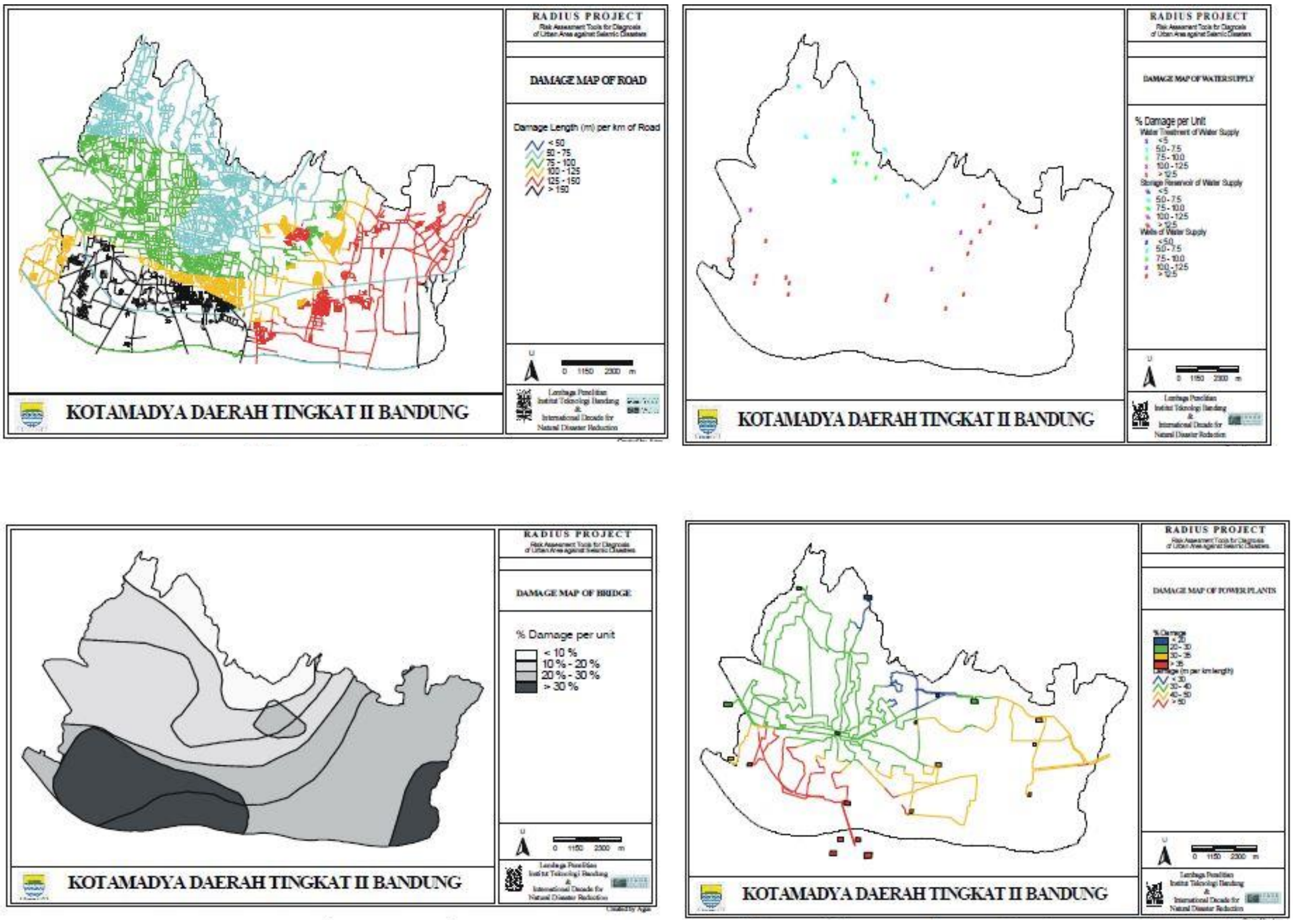

Figure 2.4 Damage map of Road network, Water Supply, Bridge and Power plant

Source: (UN IDNDR, 2000)

2.4 Evacuation Area

Evacuation is an action for handled emergency situations. Evacuation is a process of moving people from unsafe place to safer place to rise urban safety. Therefore, it is important to plan immediate shelter for evacuation area to allow safe evacuation of resident straight after a disaster.

Evacuation area/shelter is one of the primary needs of the affected people in the post-earthquake phase(Soltani, Ardalan, Boloorani, Haghdoost, & Hosseinzadeh-Attar, 2014) Temporary shelters usually established as disaster prevention facilities in densely populated urban areas in developed countries.

Temporary shelter may be in form a public shelter, refuge at friend's house, a shelter under a plastic tent or any other instant form. Temporary shelters are used to move people immediately after a disaster. Usually, people stay in temporary shelters for days or weeks until improved solutions are provided(Hany Abulnour, 2014).

In an ideal type temporary shelter it includes three phases. These are immediate sheltering, short term sheltering and long term sheltering (Chen et al, 2013) it can be seen from the Table 2.2.

Table 2.2 Shelter needs in post-disaster situations.

	Temporary Shelter		
Shelter type	**Immediate shelter (IS)**	**Short-term shelter (SS)**	**Long-term shelter (LS)**
Time	For the first day	One day to a week	A week to a month
Required Area	Total ≥ 2000 m^2 Per capita ≥ 1 m^2	Total ≥ 10.000 m^2 Per capita ≥ 2 m^2	Total ≥ 30.000 m^2 Per capita ≥ 3 m^2
Purpose	Preventive	Preventive	Preventive
Major functions	Provides easily prepared food, water, emergency medical care	Provides food, water, tents, emergency medical care	Provides food, water, tents, lavatories, cooking facilities, medicines, fire control, vaccinations, temporary storage

Source: (Chen et al, 2013)

The SPHERE handbook was the most extensive document in shelter and settlement standard for covered living space, give a guideline plan for immediate shelter, short term shelter and long term shelter. It recommends an area in excess of 3.5 M^2 per person to meet requirements of typical household activities. The overall surface area per person, including communal space for cooking, roads and footpaths, educational facilities, administration etc., within temporary communal settlements should be 45 M^2 (The SPHERE Project, 2011).It is also imply by (UNHCR, 2007) that the recommended minimum surface area is 45 M^2 per person when planning a refugee camp (including kitchen/ vegetable gardening space). However, the actual surface area per person (excluding garden space) should not be less than 30 M^2 per person.

Moreover , criteria for site selection temporary shelter following earthquake from several literatures and standards (The SPHERE Project, 2011; UNHCR, 2007; IOM, 2012;Chu & Su, 2012; Kılcı et al., 2015; Liu et al., 2011; Omidvar et al., 2013; Wei et al., 2012) can be grouped into 3 broad aspects it can be seen in the Table 2.3 below.

Table 2.3 Criteria for site selection temporary shelter following earthquake

Main Category	Criteria	Definition
Location and size	Accessibility to the site	Refers to the easiness for getting to the shelter from the affected area
	Proximity to building affected	Shelter should be evenly distributed so that citizens can arrive there quickly before and after disaster
	Suitable size	Refers to effective refuge area of the sites
Disaster risk	Suitable distance from geological hazards	Shelters should be keep away from seismic active, fault, earthquake, landslide, liquefaction, etc.
	Low land slope	Land slope steeper than 25 degree are considered to have a high risk of geo hazards whereas those that less than 5 degree are regarded as stable and secure
Basic service & infrastructure	Water supply	Water network availability

Source: (The SPHERE Project, 2011; UNHCR, 2007; IOM, 2012;Chu & Su, 2012; Kılcı et al., 2015; Liu et al., 2011; Omidvar et al., 2013; Wei et al., 2012)

2.5 Urban green space suitability analysis

Land use suitability and mapping is one of the most suitable applications of GIS for planning and management (Malczewski, 2004). It have aims to determine the most relevant spatial pattern for future land use according to specify criteria of some activities.
The land used suitability have their foundation from the hand-drawn overlay techniques by American architects in the late 19th and 20th century. Next, based previous study (McHarg, 1969) proposed a procedure for suitability analysis by mapping the attribute data, presenting this attribute data into transparent individual map using light to dark shading (low to high suitability) and overlay this transparent individual mapping to create overall suitability mapping (Malczewski, 2004).

The overlay methods, perform fundamental role in many GIS application. This methods also use as one approach in advanced land use suitability analysis such as Multi Criteria Decision Analysis (MCDA) (Malczewski, 2004). GIS-based MCDA is an operation that merge and convert non spatial and spatial data into a decision. There is two important part of spatial MCDA. First, the GIS capacity of data acquisition, storage, retrieval, manipulation and analysis geographical data. Second, the multi criteria decision making to combine geographical data and decision maker's choice into a decisions (Malczewski, 2004).

The application of GIS-based MCDA has been used to locate and select the most suitable areas for new urban forests in Ghent, Belgium (Van Elegem, Embo, Muys, & Lust, 2002) and it also used in Isparta, Turkey to identify and select the most suitable area for new urban forest. It proved to be practical way to select areas for new urban forest in Isparta (Gül, Gezer, & Kane, 2006).

Decision problems that link to geographical data are specify as spatial decision problem. The integration of MCA and GIS has been extensively use to solving spatial problems in urban assessment and planning (Chen, 2014). Planning and decision-making are nearly related. They are different phases of the problem solving process (Sharifi & Rodriguez, 2002) has establish a framework for planning and decision-making process. In the table 2.4 below, the fundamental elements of this study framework are briefly described.

Table 2.4 Framework for planning and decision-making

Phase	Activities
Intelligence (Process model)	a. Development of a conceptual framework for study area: -Problem identification; - Definition of the criteria structure;
Design (Planning model)	b. Design of proper locations for the evacuation area by: -Determination of constraint and factor -Performing a spatial multi-criteria evaluation using the criteria structure and the set of constraints to produce a suitability map for urban green as evacuation area ;
Choice (Evaluation model)	c. Evaluation : -Evaluate the selection of candidate evacuation area

2.6 Spatial Multi Criteria Evaluation

MCDA can be classified into 2 major methods multi attribute decision making (MADM) and multi objective decision making. MADM have a limited number of alternatives/options, whereas in MODM have an infinite number of alternatives/options to choose from. Multi-criteria evaluation is a multi-attribute decision making (or MADM) method (Sharifi, Herwijnen, & Toorn, 2004).
Multi Criteria Analysis is a tool that create for complex multi criteria problem that add qualitative and/or quantitative aspects of the problem in decision making process. The following steps are commonly part of Multi Criteria Analysis (Gül et al., 2006) : Form the decision context; determine the options to be appraised; determine objectives and criteria; scoring; weighting; merge the weights and scores for each option to derive an overall value; and examine the result;. To spatially implement multi criteria analysis it used Spatial Multi Criteria Evaluation (SMCE) module of Integrated Land and Water Information System (ILWIS) (ITC, 2001). SMCE is an essential way to make policy relevant information about spatial decision problems to decision makers.
Figure 2.5 below show the framework of Spatial Multi Criteria Evaluation (Zucca, Sharifi, & Fabbri, 2008). There are two paths for evaluating the performance of the alternatives involved in the problem. Both paths have two steps: spatial aggregation (SA) and multi criteria analysis (MCA) the difference between this two paths are the order of the steps are taken. Path 1 perform spatial aggregation followed by multi-criteria analysis meanwhile Path 2 start with multi criteria analysis followed by spatial aggregation.

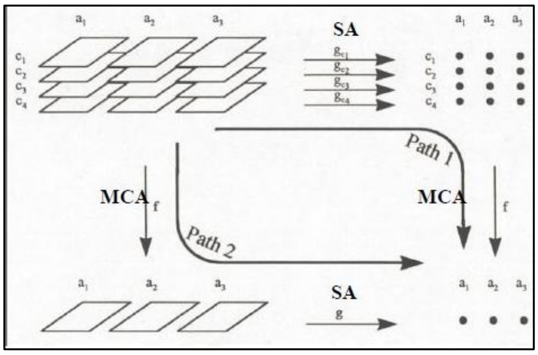

Figure 2.5 Framework of a spatial multi-criteria problem

Source : after van Herwijnen (1999) in (Zucca et al., 2008)

2.7 Analytic Hierarchy Process

To determine the weight values between criteria, the Analytic Hierarchy Process (AHP) was adopted. The AHP model, developed by (Saaty, 1980) is among the most popular methods of multi-criteria decision. It is based on the representation of a decision problem using a hierarchical structure on a ratio or ordinal scale. In AHP the decision maker has to make a comparison for every pair of criteria: first qualitative which is then quantified on a scale from 1 to 9 see Figure 2.6. The method then creates a matrix containing the pairwise comparison judgements for the criteria, from which a priority vector is derived representing the relative weights of such elements (Sharifi et al., 2004)

Inensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to objective
3	Weak importance of one over another	Experience and judgment slightly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Demonstrated importance	An activity is strongly favored and its dominance demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between the two adjacent judgments	When compromise is needed

1/9 1/8 1/7 1/6 1/5 1/4 1/3 1/2 1 2 3 4 5 6 7 8 9

Less Important ← → More Important

Figure 2.6 Scale of relative importance

Source: (Saaty, 1980)

The AHP can give a methodological framework that can both detect and correct the inconsistencies in judging the relative importance of factors in a site suitability analysis This method is commonly used in landscape planning and assessment and in site-suitability analyses (Du, Zhang, & Wang, 2012)

3. RESEARCH METHODOLOGY

This chapter discusses the methodology framework and strategy to establish the suitability factor from evacuation area requirements, and characteristic of urban green spaces. Next, for assessing urban green space suitability will used SMCE (spatial multi criteria evaluation) module of ILWIS. Lastly, evaluate the method on the basis of the Bandung case to identify appropriate urban parks and the interventions to make unsuitable areas is suitable.

3.1. Study area

Bandung city serves as capital city of West Java Province and located about 140 km from the country capital Jakarta (see Figure 3.1). The altitude varies from 700 m in the southern parts of Bandung to 1300 m in the northern city area, Bandung was basically developed as a resort city in the 1800s by the Dutch Indies government, due to its rich natural setting and comfortable (Tarigan et al., 2015). The montane climate in the Priangan Mountains fit well with the demands of European colonists for good living conditions. A city development was planned for the northern part of Bandung from the 1920s onward, and the idea to apply the garden city concept come up due to its environmental balance as major consideration(Abendroth, Kowarik, Müller, & Von der Lippe, 2012).

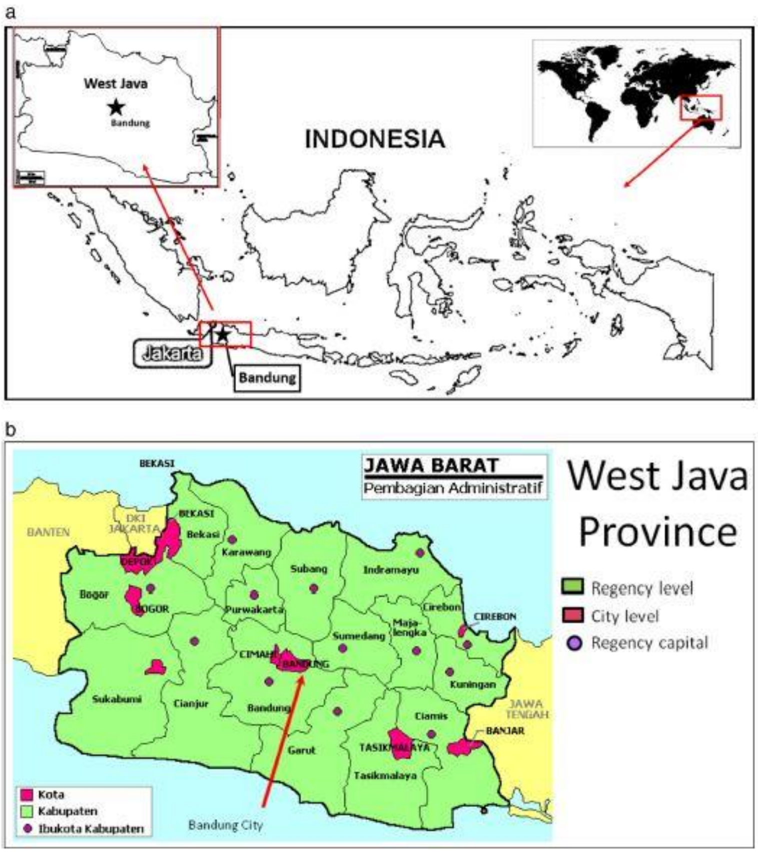

Figure 3.1 The position of Bandung City with its country capital (Jakarta), neighbouring provinces, cities and regencies

Source: (Tarigan et al., 2015)

One of city facilities was built by Dutch Indies government for applied the garden city concept is the development of urban parks in Cibeunying area (Kunto, 1984) for example Malukenpark (Maluku Parks) located adjacent to the Colonial Army Command Headquarters; Tjitaroemplein (Citarum Parks) behind the Sate building (now has changed into Mosque Istiqamah); Oranjeplein (now changed into Scout Parks) built early 1920's in a residential area of Jalan Riau; Ijzermanpark (Ganeca Parks) in front ITB campus; and Pieterspark (Dewi Sartika Parks) was built in front of the Bandung City Hall. Nowadays, mostly parks remain at their original location and but the size and function is different due to a development in city area.

Bandung city covers an area of 16.730 hectares, which is divided into 30 districts. According to Spatial planning of Bandung Municipality (Government of Bandung Municipality, 2011b) in order to accommodate the city's future activities and developments, the spatial structure of the Bandung City from 30 districts can divided into 8 Sub city (*Sub Wilayah Kota*) namely Sub City Bojonegara, Cibeunying, Tegallega, Karees, Arcamanik, Ujungberung, Kordon and Gedebage (Government of Bandung Municipality, 2011b) see Figure 3.2.

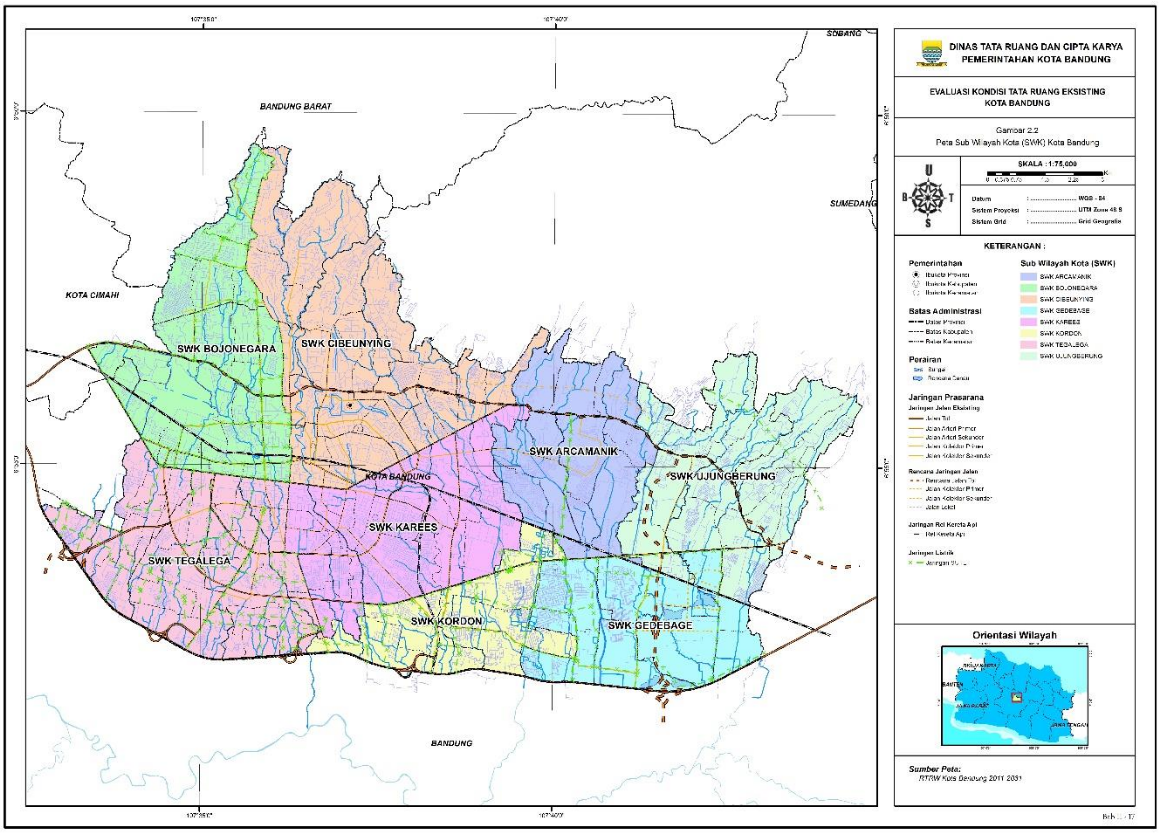

Figure 3.2 Sub City Map

Source: (Government of Bandung Municipality, 2011b)

Currently the area of urban green spaces of Bandung municipality has reached 1910.5 hectares or 11.4% of the city. Moreover the urban parks area is 275.6 Ha or 1.6 % of the city (Government of Bandung Municipality, 2011b). The highest number of urban park area is located in Cibeunying sub city with 147 urban park, while the lowest number located in Tegallega sub city with 28 urban park (see Table 3.1).

From the Green Space Masterplan Report (Government of Bandung Municipality, 2011a) Cibeunying sub city has been known to have historical urban parks from the Dutch Indies government where quite a lot of them are still functioning well today. Parks Hierarchies can be said to be complete, ranging from local park (*Taman RT*), neighborhood park (*Taman RW*), sub-district park (*Taman Kelurahan*), district park (*Taman Kecamatan*) until city park and and also the hierarchies of green lines from neighborhood until collector and arterial roads. Urban green spaces that exist in this sub city can be considered to have had good connectivity.

Contrastly, Tegallega sub city is the area with lowest number of urban parks because of high population density in that area. There is almost no adequate green space and no connectivity between green spaces also. With higher population density its need adequate green space for the citizen.

Bojonegara and Karees sub city has urban parks and green lines adequate in some areas, although not the entire hierarchy has been fulfilled. Similarly, connectivity between green spaces in some areas is quite good, but in some other areas there is a lack connectivity .

Ujungberung and Gedebage sub city is included in the expansion of residential area , in here the neighborhood parks and green lines can be found in new residential area

Table 3.1 Urban parks in Bandung City

No	Sub City	Urban parks
A	**Sub city Bojonegara (97 urban park)**	
1	Andir district	9.1
2	Sukasari district	4.8
3	Cicendo district	11.8
4	Sukajadi district	23.7
	Total Bojonegara sub city	49.4
B	**Sub city Cibeunying (147 urban park)**	
5	Cidadap district	11.7
6	Coblong district	23.3
7	Bandung Wetan district	15.9
8	Cibeunying Kidul district	1.4
9	Cibeunying Kaler district	3.0
10	Sumur Bandung district	6.2
	Total Cibeunying sub city	61.5
C	**Sub city Tegalega (28 urban park)**	
11	Astana Anyar district	0.9
12	Bojongloa Kidul district	23.4
13	Bojongloa Kaler district	1.0
14	Babakan Ciparay district	6.9
15	Bandung Kulon district	15.8
	Total Tegalega sub city	47.9
D	**Sub city Karees (78 urban park)**	
16	Regol district	20.9
17	Lengkong district	8.2
18	Batununggal district	27.9
19	Kiaracondong district	0.9
	Total Karees sub city	57.9
E	**Sub city Arcamanik (89 urban park)**	
20	Mandalajati district	10.1
21	Antapani district	2.3
22	Arcamanik district	16.4
	Total Arcamanik sub city	28.8
F	**Sub city Ujungberung (62 urban park)**	
23	Cinambo district	5.0
24	Panyileukan district	2.8
25	Ujungberung district	0.7
26	Cibiru district	0.8
	Total Ujungberung sub city	9.4
G	**Sub city Kordon (52 urban park)**	
27	Bandung Kidul district	2.6
28	Buahbatu district	4.8
	Total Kordon sub city	7.4
H	**Sub city Gedebage (49 urban park)**	
29	Gedebage district	10.0
30	Rancasari district	3.2
	Total Gedebage sub city	13.2
	TOTAL all sub city	275.6

Source:(Government of Bandung Municipality, 2011b)

3.2. Methodological framework

Methodological framework below (Figure 3.3) was developed to achieve the research objective and answered the research questions. It is classified into four sub objective, First determine the requirements of evacuation area. Second, the characteristic of urban green space. Third selecting the suitability factor, develop criteria tree, standardization and weighting. Lastly, doing the suitability analysis with SMCE to assessing the suitability of urban green space.

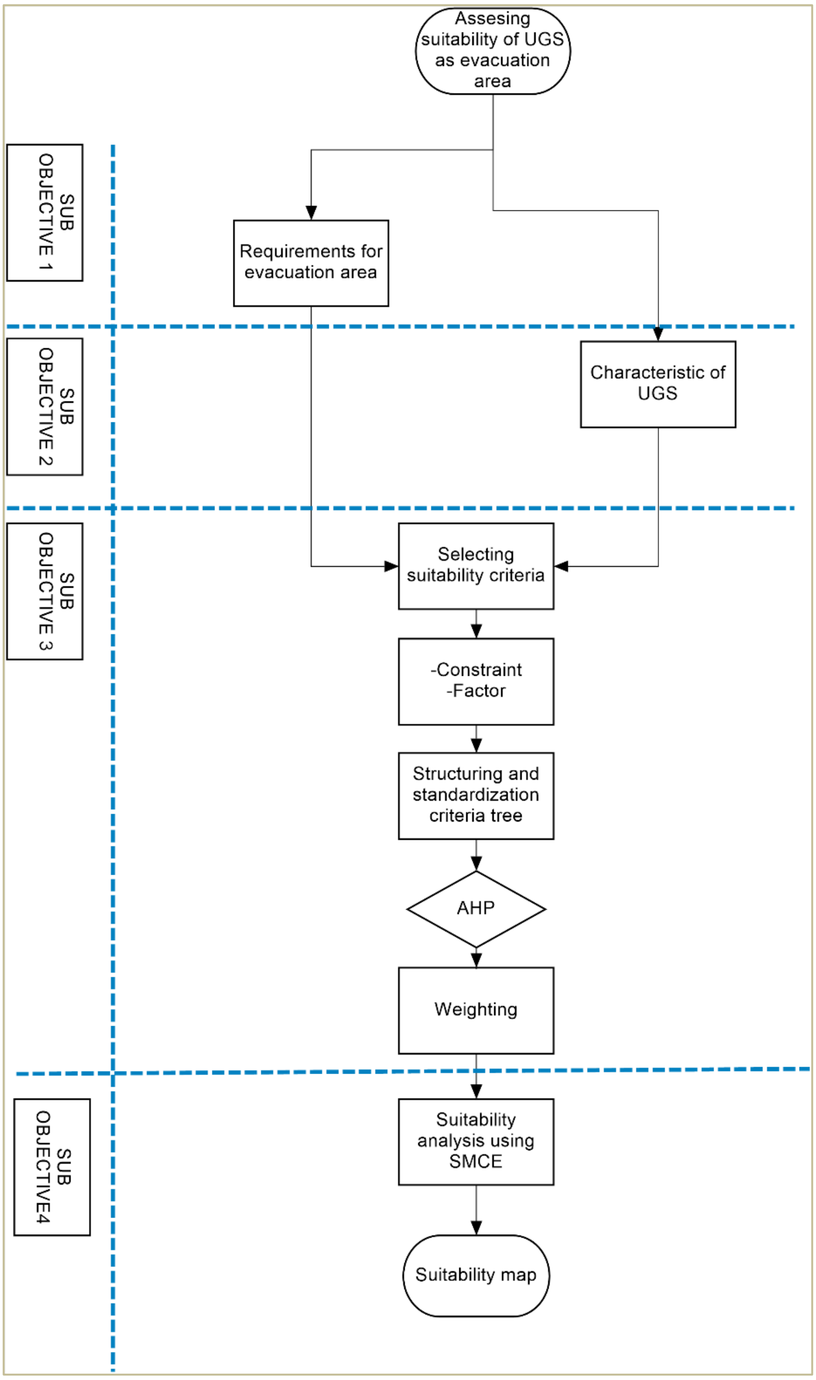

Figure 3.3 Methodological framework

3.3. Data collection

Primary data will collected through pairwise questionnaires designed for the expert. This questionnaires is to determine the weight for the suitability factor. The experts are local government representative, urban planning expert and academician, and disaster mitigation expert and academician.

Secondary data area non spatial data and spatial data. Non spatial data was mainly review of relevant literature, journals, articles, seminar proceeding, working paper, published government document such as the Spatial Planning Report 2011-2031, The Green Spaces Masterplan report of Bandung Municipality, Bandung City in Figures and RADIUS final report.

Spatial data was obtained from the Development Planning Agency (BAPPEDA) of Bandung municipality. The spatial data (*shp) are in vector format at a scale of 1:70.000, which is part of the dataset of the Spatial Plan of Bandung Municipality 2011-2031. The DEM from Aster Terra imagery was used to generated slope in Bandung Municipality.

Table 3.2 List of spatial data to be used in the study

No	Maps	Type	Year	Source
a.	Administrative Boundary (District)	Shp	2011	Development Planning Agency
b.	Urban green spaces	Shp	2011	Development Planning Agency
c.	Road network	Shp	2011	Development Planning Agency
d	Building	Shp	2011	Development Planning Agency
e	Landslide	Jpeg	2000	RADIUS final report
f	Earthquake Intensity Zone	Jpeg	2000	RADIUS final report
g.	Lembang fault	Jpeg	2000	RADIUS final report
h.	Water network	Shp	2011	Development Planning Agency
i.	DEM from Aster Terra	Img	2014	USGS/ITC

Table 3.3. List of non spatial data to be used in the study

No	Document	Type	Year	Source
a.	Green Spaces Masterplan report	Pdf	2014	Development Planning Agency
b.	Bandung City in Figures	Pdf	2014	Central Bureau Statistic of Indonesia
c.	RADIUS final report	Pdf	2000	United Nations

3.4. Assumptions

There are several assumptions in this research which can be summarized as follows:

- People in damage building it is assumed need to evacuate
- The number of refugee is estimated by multiply the damaged building based on The Radius Project with the average of person/household as stated in (Central Bureau Statistic of Indonesia, 2014)
- The evacuation area is limited to temporary shelter. In this research, based on previous study by (Chen et al,2013) the minimum area needed for is 2000 M^2
- Based on previous (The SPHERE Project, 2011) the minimum area needed for one person in temporary shelter is 3.5 M^2
- The urban green spaces that used in this study is limited to public urban park owned by government

- The water network for the suitability factor is assumed still working after the earthquake happen
- The road network for the suitability factor is assumed still working after the earthquake happen
- All area of candidate urban green spaces is assumed can used as evacuation area

3.5. The requirements for evacuation area

Earthquakes, as an inherently unpredictable, cause people homeless because of destruction of houses, whether completely or partially. Moreover it is also results in death, injury, disturbance in livelihood. Evacuation area/shelter is one of the primary needs of the affected people in the post-earthquake(Soltani et al., 2014).

In an ideal type, it includes four phases(Félix, Branco, & Feio, 2013). These are emergency sheltering, temporary sheltering, temporary housing and permanent housing : (1) emergency shelter is a place where refugee stay for a short period of time during the disaster(house of a friend or in a public shelter); (2) temporary shelter is used for an expected short stay, maximum in a few weeks after the disaster (tent, a public mass shelter, etc).; (3) temporary housing is the place where the refugee can reside temporarily usually between six months to three years(a prefabricated house, a rented house, etc).; (4) permanent housing is a return to the rebuilt house or resettle in a new one to live permanently.

Temporary shelter usually use for a community in the post-earthquake. The development of a model for selecting temporary shelters can serve as the basis for the improvement of operation and process coordination in an emergency situation (Nappi & Souza, 2015). Therefore, it is necessary to identify criteria to be considered in the developing of such system since on the one hand they are not permanent and do not need to follow the permanent housing standards, and on the other hand, they should provide the residents with some minimum living standards requirements (Forouzandeh, Hosseini, & Sadeghzadeh, 2008). In an ideal type temporary shelter it includes three phases. These are immediate sheltering, short term sheltering and long term sheltering (Chen et al, 2013) it can be seen from the Table 2.2.

Site selection is an important activity that can result in the success or failure of temporary shelter programme. Moreover, the specification of appropriate criteria is the most important matter with regard to site selection In previous disasters, site selection only involved basic criteria, such as land ownership and land per capita, and mostly resulted in the selection of arid land (Omidvar et al., 2013). To specify the criteria, perfect identification of cultural, economic, geographical, political, and social information is needed (UNHCR, 2007).

Evacuation areas should be located in safe area. Available vacant land as well as green open spaces and open areas are generally considered as safe area. These area should have a basics living requirements (water, toilet etc), enough space and located outside the hazard areas. Criteria for site selection temporary shelter following earthquake from several literatures and standards (The SPHERE Project, 2011; UNHCR, 2007; IOM, 2012; Chu & Su, 2012; Kılcı et al., 2015; Liu et al., 2011; Omidvar et al., 2013; Wei et al., 2012) can be seen in Table 3.4.

Table 3.4 Criteria for site selection temporary shelter

No	Aspects	Criteria
1	**Location and Size**	**a Distance from building** Shelter should be evenly distributed so that refuge can arrive there quickly before-in-after disaster it is advisable to have walking distance between 5-10 min (Wei et al., 2012). The nearby principle, the nearer the evacuation area to populated areas, the faster and more comfortably people can seek.
		b.Distance from road network The proximity to main roads and accessibility of facilities (water, sanitation, administration and security, food distribution, health, and community service), should be considered when selecting the site. There also should be appropriate access to and from the site for emergency services to get sufficiently close to shelters (IOM, 2012)
		c. Capacity of accommodation (Urban parks area divided by 3.5 M^2 accounts for accommodation persons) A temporary shelter for evacuation area is designed to provide enough open space to accommodate refugee. The SPHERE handbook (The SPHERE Project, 2011) was recommends an area in excess of 3.5 M^2 per person to meet requirements of typical household activities. Moreover, the number of people the shelter serves (capacity) should be considered a large camps of over 20,000 people should generally be avoided (UNHCR, 2007).
2	**Disaster Risk**	**d. Slope** If the seismic shelter for evacuation is located in steeper slope >25°, the shelter cannot serve as a refuge. The lower possibility of steeper slope means greater security of the shelter. The main function of the evacuation area is to reduce risks at the time of disaster, to establish security of refugees by minimizing risks
		e. Landslide and Earthquake Intensity Zone Based on RADIUS report Bandung city have landslide prone area in the north area of city and also have 6 earthquake intensity zone ranging from 8-9 MMI Scale. Earthquake, landslide, collapse, debris flow, soil liquefaction and ground depression, etc. are major geological hazards at seismic shelter for evacuation. It should be ensured that the shelter is not affected by geological hazards.
3	**Basic service & Infrastructure**	**f. Distance from Water Network.** Water is one of the most imminent needs of humankind. Water is used for the continuity of biological activities, cooking, cleaning, etc. Temporary shelter for evacuation area should be able to provide water service. Therefore, such a site should be located as near as possible with water network.

Source: (The SPHERE Project, 2011; UNHCR, 2007; IOM, 2012; Chu & Su, 2012; Kılcı et al., 2015; Liu et al., 2011; Omidvar et al., 2013; Wei et al., 2012)

3.6. The characteristic of urban green spaces

There are 15 types of green open spaces based on Ministerial Regulation of Public Works Indonesia No. 05/PRT/M/2008. This study will first determine which of the green space types has the potential to be used as evacuation area. Not all type of urban green spaces can be used as evacuation area due to their existing function, urban parks is suitable to be used as evacuation area because has characters of a large quantity, wide distribution and easy accessible. It also have benefit as disaster prevention and reduction for example prevent fire from spreading, prevent flood from overflowing and provide emergency shelter from a disaster (Fan et al., 2012). From on Ministerial Decree of Public Works Indonesia also divide urban parks hierarchy into city and neighborhood parks (local park (*Taman RT/RW*), sub-district park (*Taman kelurahan*) and district park (*Taman kecamatan*)) see Table 3.5.

Table 3.5 Type of urban park

Type of urban park	Size	Location
Local park	1.250 M^2	In the centre of local activities
Sub district park	9.000 M^2	Associated with school or sub-district centre
District park	24.000 M^2	Associated with school or district centre
City park	144.000 M^2	In the centre of urban area

Source : Ministerial Regulation of Public Works Indonesia No. 05/PRT/M/2008

Type of urban green spaces used as evacuation area was selected using tools select by attribute in ArcGIS. Additional characteristics will be collected for each of the open spaces that may assist in determining their suitability (capacity, proximity to building affected, proximity to road network, and proximity to water network). The minimum required area for temporary shelter based on previous study (Chen et al, 2013) is 2000 M^2. The urban parks framework shows on Figure 3.4.

Ownership and usage rights of each evacuation area should be predetermined and any necessary permission should be obtained. In most countries land for the development of refugee camps is limited. Often, it is used public land by the government (Omidvar et al., 2013 . Government owned spaces should be preferred, as these can be managed easier than privately owned open spaces . Park can be owned both by private and public. However, in this study only parks owned by public will be researched.

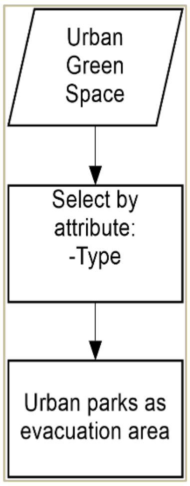

Figure 3.4 Urban park framework

The existing location of Urban parks in Bandung Municipality can be seen on the Figure 3.5 below. The urban parks is represented with green colour and the city area is represented with grey colour. The large area of urban parks mostly located near the road network.

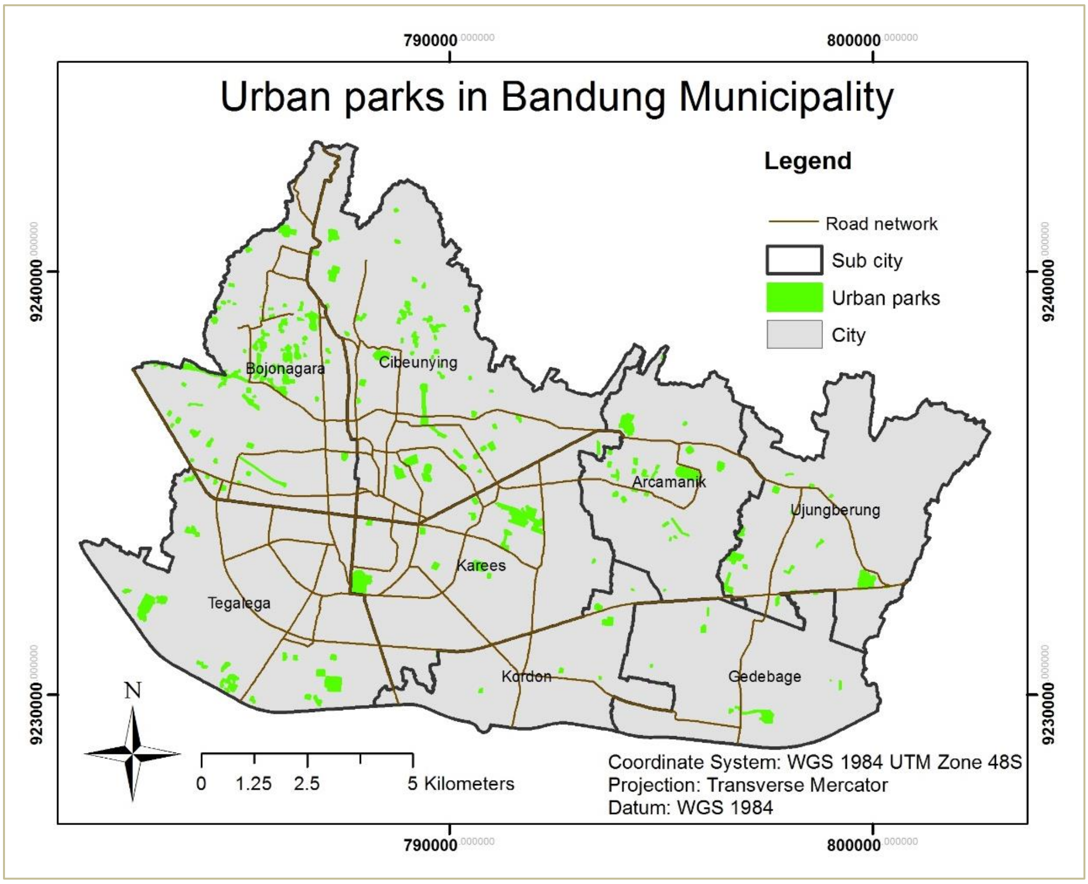

Figure 3.5 Map of urban parks in Bandung Municipality

3.7. Method for assesing urban green spaces suitability as evacuation area

Methods used for assessing suitability is Multi Criteria Evaluation. Spatial Multi Criteria Evaluation is an application in ILWIS that support a user in doing Multi Criteria Evaluation (Sharifi et al., 2004). The input of application is a set of raster maps of certain area (criteria). Next, identifying and structuring criteria that should be considered for assessing suitability of urban green space (problem structuring). Then added the criteria into the criteria tree whereas criteria are grouped, standardized (convert the values and classes of criteria into a common scale) and weighted (different priorities will be assigned to each criteria and group of criteria) map. The output is overall suitability of each pixel in the map (composite index map)

3.7.1. Spatial data preparation

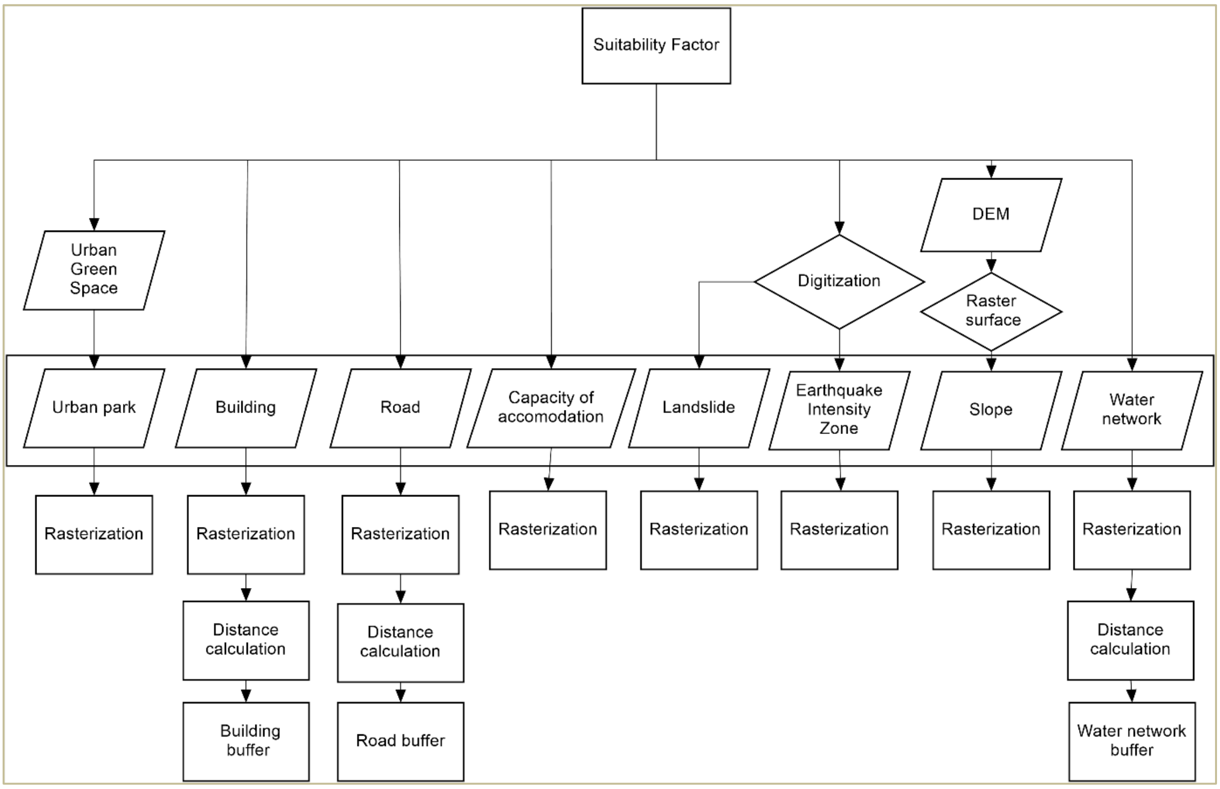

Figure 3.6 Data preparation framework

After determining the appropriate factors, spatial data representing each factor were prepared. The majority of the data needed was in a format compatible for import to the geography information system (GIS). The data that could not be incorporated into GIS required additional processing. Assessing suitability analysis of urban green spaces with SMCE-ILWIS required data in raster format. As it has been mentioned above that most of available data are in vector format (.shp). All shape file should be transferred into the raster maps through the operation of rasterization in ILWIS.

Moreover for slope its get from Digital Elevation Modelling (DEM) from .Aster Terra digital imagery with tool Raster Surface in ArcGIS can generated slope from DEM and for landslide and earthquake intensity zone its must digitized first because the available data is in jpeg. After all data are in raster format, for generated buffer from raster feature (building, road network, active fault and water network) it used distance calculation tools. The Figure 3.6 above explain the data preparation framework.

3.7.2. Development criteria tree and standardization

In constructed criteria tree in SMCE it is included the concept that follow (see Figure 3.7):

a) Constraints (Zucca et al., 2008) : conditions which are not good for the area and should be excluded from suitability analysis. In the composite index map the excluded areas will get a nil (0) value while the remaining area will get value 1
b) Factor (Zucca et al., 2008): criteria that contribute to a certain degree to the output. There are two type of factor : benefit criteria is a criteria that contributes positively to the output (the more the values the better it is)and cost criteria is a criteria that contributes negatively to the output (the less the value the better it is)
c) Group of factor (Zucca et al., 2008): A combination of factor that define a sub goal
d) Standardization (ITC, 2001): After selecting input data for criteria (factors or constraint), the input maps need to be standardized from their original to the value range of 0 - 1. The input data are various maps or attribute column with a value, class or bool domain and express different measurement unit. To deal with this, they have to standardize i.e. transformed to the same unit. Standardization of factor (benefits and costs) have output values range between 0 and 1 meanwhile, for constraint the output values are either 0 and 1.

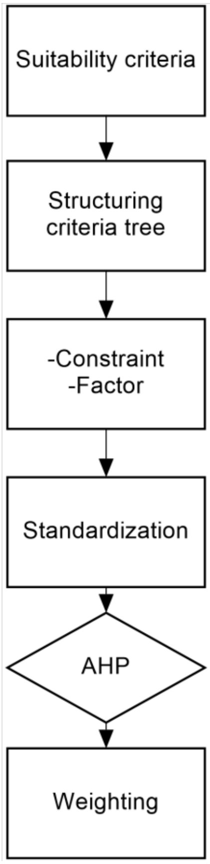

Figure 3.7 Development criteria tree and standardization framework

Depending on the domain of the map or attribute column standardize can divided into three type(Hengl, 2015):

- Standardize Value Input
  -Maximum standardization, dividing the input values by the maximum value of the map
  -Interval standardization, linear function that uses the minimum value and the maximum value of the input maps
  -Goal standardization, linear function that uses a specified minimum and maximum value of the input maps.
- Standardize Boolean Input: indicate a value between 0 and 1 for 'True' values, and similarly indicate a value for 'False' values. For a constraint, just indicate the condition that should be met and can use for any futher calculation.
- Standardize Class Input: select a column in a table that list a value between 0 and 1 for every domain item.

Constraints indicator:
- The evacuation area cannot be built on urban green spaces which have area < 2000 M^2
- The evacuation site cannot be located on a terrain with a slope > 25°
- The evacuation area cannot located on landslide prone area

Table 3.6 Constraint

Constraint	Standardization
Urban parks	Minimum method. To obtain a standardized value of 1, all areas must have a value larger than 2000 M^2; all other value are standardized to 0.
Slope	Maximum method. To obtain a standardized value of 1, all areas must have value smaller than 25°; all other value are standardized to 0.
Landslide	Boolean input. TRUE passes, FALSE will be blocked. No landslide area passes, landslide prone area will be blocked. Landslide prone area is standardized to 0; no landslide standardized to 1.

The factors need to be standardized from their original value to a uniform suitability rating scale. There are five classes for each factor based on their suitability as follows; 0) very low, 1) low, 2) medium, 3) high and 4) very high. The boundary data values for suitability criteria are adopted from government regulation, literature review and the data analysis. This standardization will be used as threshold in ILWIS operation

Table 3.7 Suitability factor

		Potential Rating				
No	**Factor**	**0**	**1**	**2**	**3**	**4**
1	Distance from building (Cost criteria)	1000-801 m	800-601 m	600-401 m	400-201m	200-0 m
2	Distance from road network (Cost criteria)	1000-801 m	800-601 m	600-401 m	400-201m	200-0 m
3	Capacity of accommodation (Cost criteria)	50.000-20.001 refugee	20.000-16.251 refugee	16.250-12.501 refugee	12.500-8.751 refugee	8.750-0 refugee
4	Slope <25° (Cost criteria)	50-26°	25-20°	19-15°	14-10°	10-0°
5	Earthquake Intensity Zone (Cost criteria)	5-6	4	3	2	1
6	Distance from water network (Cost criteria)	1000-801 m	800-601 m	600-401 m	400-201m	200-0 m

3.7.3. Weighting

Assigning weight is needed in order to indicate the relative importance of these factor with respect to the main goal or sub goal

Within SMCE there is three options to assign weights (Hengl, 2015)

- Direct Method: The weight values is indicate by the user himself. Then, weights are automatically normalized.
- Pairwise Comparison: The weight values is indicate from the unique pairs and assigns Saaty weights (in word) by the user. Then, normalized weights are calculated.
- Rank Ordering: The weight values is indicate from a rank-order by the user. Then, normalized weights are calculated.

Weight have to attach to all the factors within a group and to the group except for the constraint no need to assign a weight because it is exclude all the areas that are not suitable.

In this study, experts are involved to give weight for each criterion using pair wise comparison. For collecting weights by the experts' opinion, AHP scale from 1to 9 was used for this analysis as shown in Figure 2.7. The pairwise comparison questionnaire was sent to four experts from government of Bandung City, Urban and Regional Planning Department ITB and Research Center for Disaster Mitigation ITB. Collected weight were analyzed in Expert Choice (EC) decision support software by using pairwise comparison matrices. Consistency ratio was also computed in EC software.

The calculation procedure as follows (Saaty, 1980): Establishment of pairwise comparison matrix A. Let C1, C2, y, Cn show the set of elements, while aij represents a quantified judgment on a pair of elements Ci, and Cj. The matrix format in pair wise comparisons describes as matrix A as follows: C1; C2; . . . ; Cn

$$A = [a_{ij}] = \begin{matrix} C_1 \\ C_2 \\ \vdots \\ C_n \end{matrix} \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix}$$

Matrix A containing the pairwise comparison judgments for the criteria, from which a priority vector is derived of relative weights for these elements (the principal eigenvector of the matrix). If A is a consistency matrix, the relations between weights Wi and judgments aij are simply given by Wi/Wj = aij (for i; j = 1; 2; . . . ; n) and C1; C2; . . . ; Cn

$$A = \begin{matrix} C_1 \\ C_2 \\ \vdots \\ C_n \end{matrix} \begin{bmatrix} w_1/w_1 & w_1/w_2 & \cdots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & \cdots & w_2/w_n \\ \vdots & \vdots & \ddots & \vdots \\ w_n/w_1 & w_n/w_2 & \cdots & w_n/w_n \end{bmatrix}.$$

It has been proved that the eigenvector corresponding to the largest eigenvalue of the matrix provides the relative priorities of the factors for example if one factor has preference, its eigenvector component is larger than that of the other (Reis et al., 2011). The largest eigenvalue (λmax) would be:

$$\lambda_{\max} = \sum_{j=1}^{n} a_{ij} \frac{W_j}{W_i}.$$

Saaty proposed utilizing consistency index (CI) and consistency ratio (CR) to verify the consistency of the comparison matrix. CI and CR are defined as follows:

$$CI = \frac{\lambda_{max} - n}{n-1} \qquad CR = \frac{CI}{RI}$$

Where;
n = the number of items being compared in the matrix
λmax = the largest Eigen value
RI = random consistency index

Table 3.8 Random consistency index

n	1	2	3	4	5	6	7	8	9	10
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

RI represents the average consistency index over numerous random entries of same order reciprocal matrices see Table 3.8. If CR ≤ 0.1, the consistency is accepted; Otherwise, if CR > 0.10 it should reformulated the original weights in the pairwise comparison matrix A until the consistency is accepted;

3.8. Evaluate the method on the basis of Bandung case

After doing standardisation and weighting at the end it will obtain the overall suitability of each pixel in the map (composite index map) . A composite index map contains the accumulated suitability for all criteria that have been standardized and weighted. Any output composite index map will have values between 0 and 1. Values near 0 represent less suitable areas By contrast, values near 1 represent suitable areas.

The calculation is based on the Weighted Sum Method that is represented by the following formula (Looijen, 2015):

$$S_j = \sum_{i}^{n} W_i \, Si_j$$

where Sj is the weighted score for pixel j in the overall suitability map, Wi is the weight for the i-th input map, and Sij is the score for the j-th pixel in the i-th map. The value of j depends on the partial attractiveness of each pixel actually occurring at the current location. The higher the weighted score Sj, the higher the suitability

For classify the composite index map into a suitability class map it is done by slicing tools in ILWIS into a limited number of classes in this study will classify into 5 classes:

Not suit	0.0
Marginally suit	0.0-0.25
Moderately suit	0.25-0.50
Suitable	0.50-0.75
Highly suit	0.75- 1

Next calculate the area for each suitability class with tools table calculation, area numbering and cross tab. After that select the“highly suitable” area, calculate the capacity and evaluate area based on existing conditions.

4. RESULT AND DISCUSSION

This chapter represents the development of a GIS-based approach to assess the suitability of urban parks as previously explained the outcomes of the analyse themselves cannot be evaluated as they are based upon outdated data, hence this chapter critically discusses the methodology of the study. In this study was used Spatial Multi Criteria Decision (SMCE) module of ILWIS-GIS. This process consists of procedures that involve the utilization of geographical data, and the decision maker's preferences according to specified decision rules. The model is built by making criteria tree, where the conditioning parameter maps are grouped, standardized and weighted. Further, evaluate the method on the basis of the Bandung case to identify appropriate urban parks and the interventions to make unsuitable areas is suitable.

4.1. SMCE for assesing urban green spaces suitability as evacuation area

4.1.1. Development criteria tree and standardization

In constructed criteria tree in SMCE it include the concept that follow::development criteria tree (defined constraint and factor) see Figure 4.1, structured in criteria tree, lastly standardized because each factor is represented by different type of map, the values and classes of all maps need to transformed into a common scale.

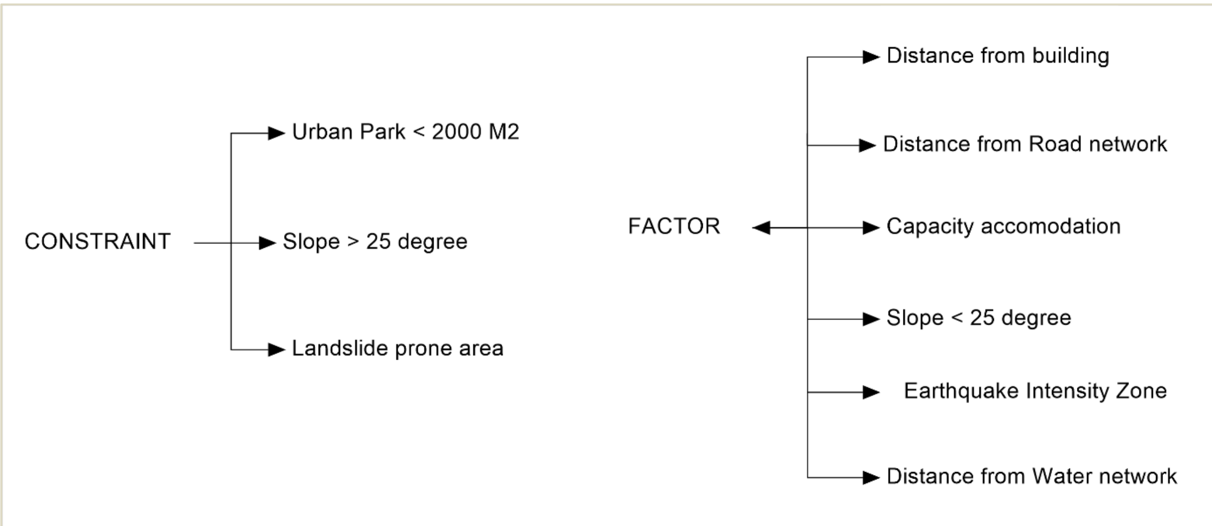

Figure 4.1 Constrain and Factor

4.1.2. Constraint

4.1.2.1. Urban parks

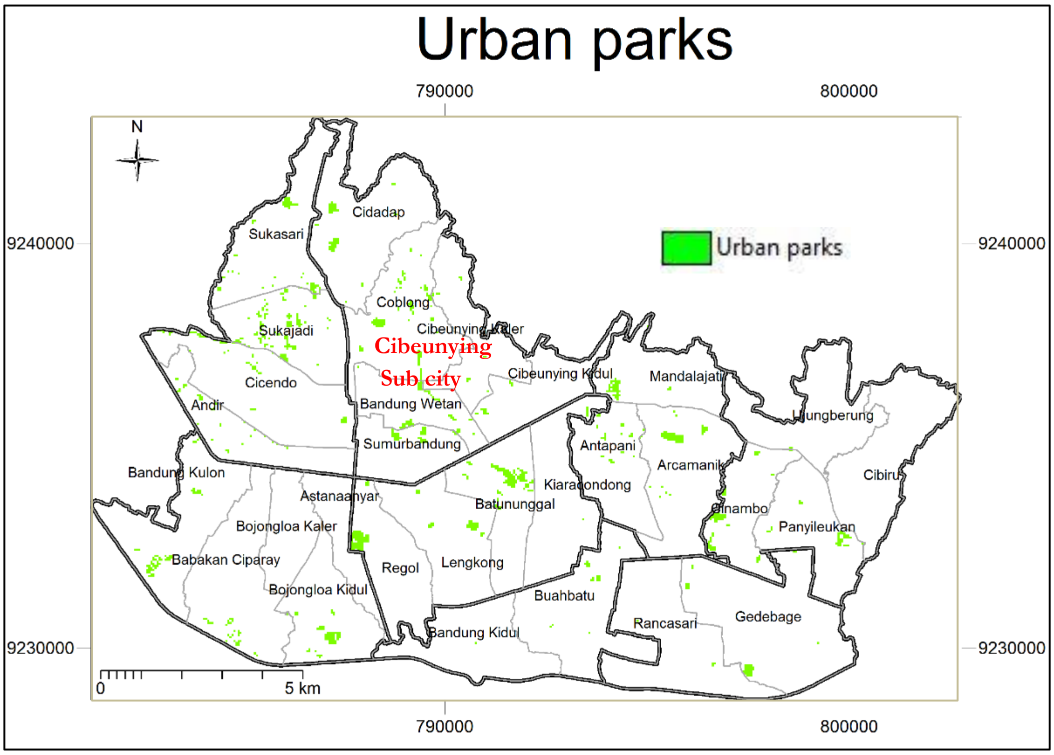

Figure 4.2 Urban parks map

Cibeunying sub city have the highest number of urban parks about 147 location and mostly is historical urban parks from the Dutch Indies government. Parks Hierarchies in that area also can be said to be complete, ranging from local park until city park.

Urban parks type based on Ministerial Regulation of Public Works No. 05/PRT/M/2008 consist of 4 type local park (minimum area 1.250 M^2), sub district park (minimum area 9.000 M^2), district park (minimum area 24.000 M^2), and city park (minimum area 144.000 M^2). The minimum temporary shelter area based on (Chen et al, 2013) is 2000 M^2. Urban parks with area less than 2000 M^2 is excluded from the suitability analysis. For constrain standardization it used minimum method. To obtain a standardized value of 1, all areas must have a value larger than 2000 M^2; all other value are standardized to 0.

4.1.2.2. Slope

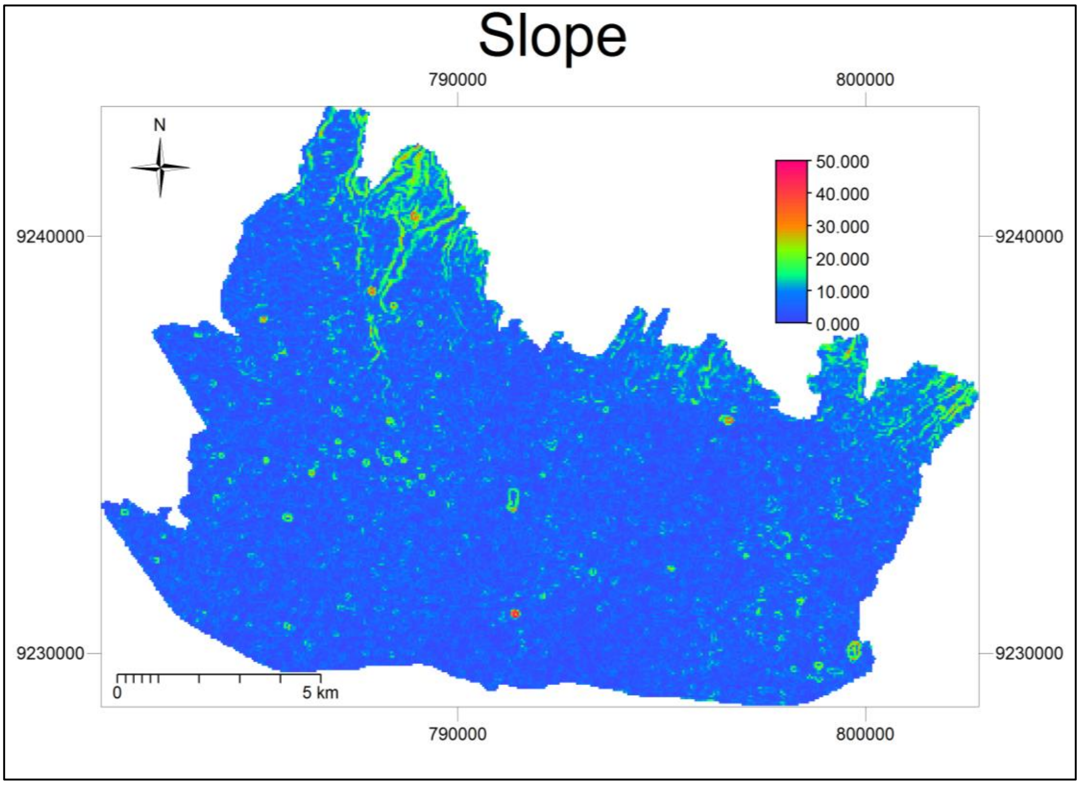

Figure 4.3 Slope map

Bandung city have slope ranging from 0 until 50 degree .Mostly is less than 10 degree except for the north area of the city slope is stepper than 25 degree. Shelter located in slopes steeper than 25 degree are considered to have a high risk of geo hazards whereas slopes less than 5 degree are regarded as stable and secure (Liu et al., 2011). For constrain standardization it used maximum method. To obtain a standardized value of 1, all areas must have a value smaller than 25 degree; all other value are standardized to 0.

Shelter should be located on flat and expansive terrains which is easy for drainage and setting up tents. In some cultures, shelters are located orientated along the slope, following the contour of the land. This is to reduce the velocity of surface water in drainage(IOM, 2012).Sites on slopes steeper than 25 degree are difficult to use and usually require complex and costly site preparations (UNHCR, 2007).

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4.1.2.3. Landslide

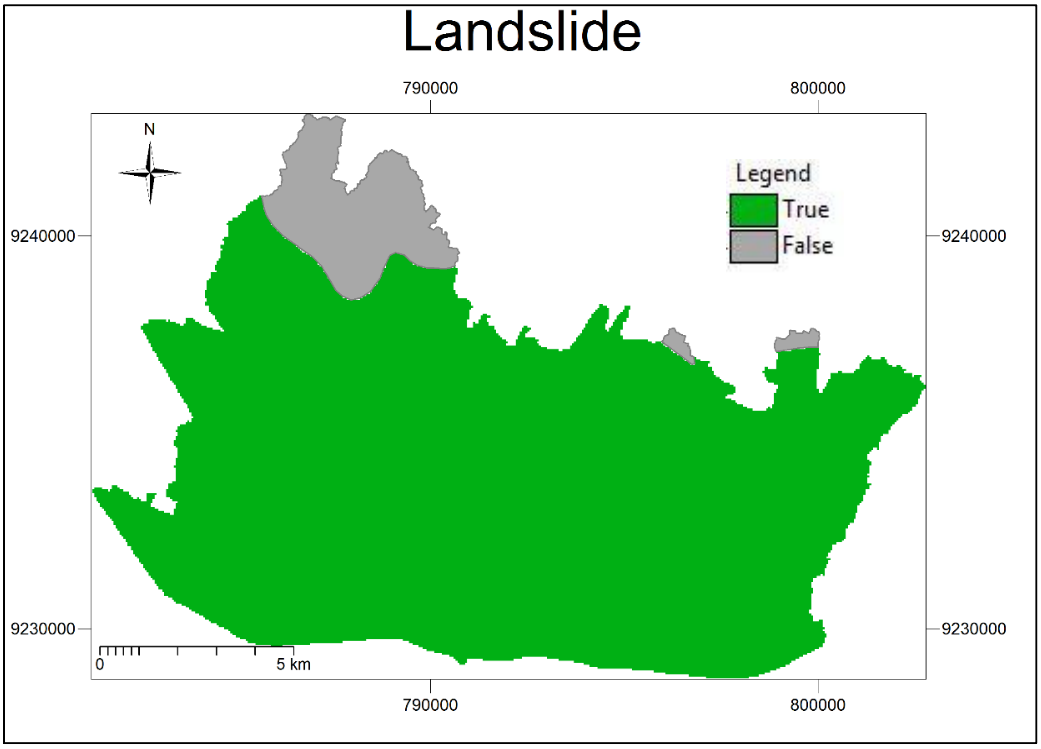


Figure 4.4 Landslide map

The risk assessment result from RADIUS project in 2000 year also identify the secondary hazards followed an earthquake. The result is a landslide prone area in the north area of Bandung area. This area will excluded from suitability analysis. For constrain standardization it used Boolean input. TRUE passes, FALSE will be blocked. No landslide area passes, landslide prone area will be blocked. Landslide prone area is standardized to 0; no landslide standardized to 1.

The main purpose of the refuge is to reduce or eliminate risks at the time of disaster, to ensure security of refugees by minimizing risk. Shelters should be keep away from the effect of geological hazard such as seismic active fault, earthquake, landslide, collapse, debris flow, soil liquefaction and ground depression, etc. (Omidvar et al., 2013). Most of the landslides occurred on slopes steeper than 15.(Qi et al., 2009).

It should be ensured that the shelter is not affected by geological hazards (Chu & Su, 2012). If the shelter itself is threatened by greater potential risks, such a site is of no value in practice. Safety is the core issue in planning and constructing seismic shelter for evacuation.

4.1.3. Factor

The selected suitability factors should be relevant to the goal and objectives of the assessment(Du et al., 2012). For any given objective, assessing one or several different factors may be necessary to achieve a complete assessment of the degree to which the objective may be achieved.

4.1.3.1. Distance from building

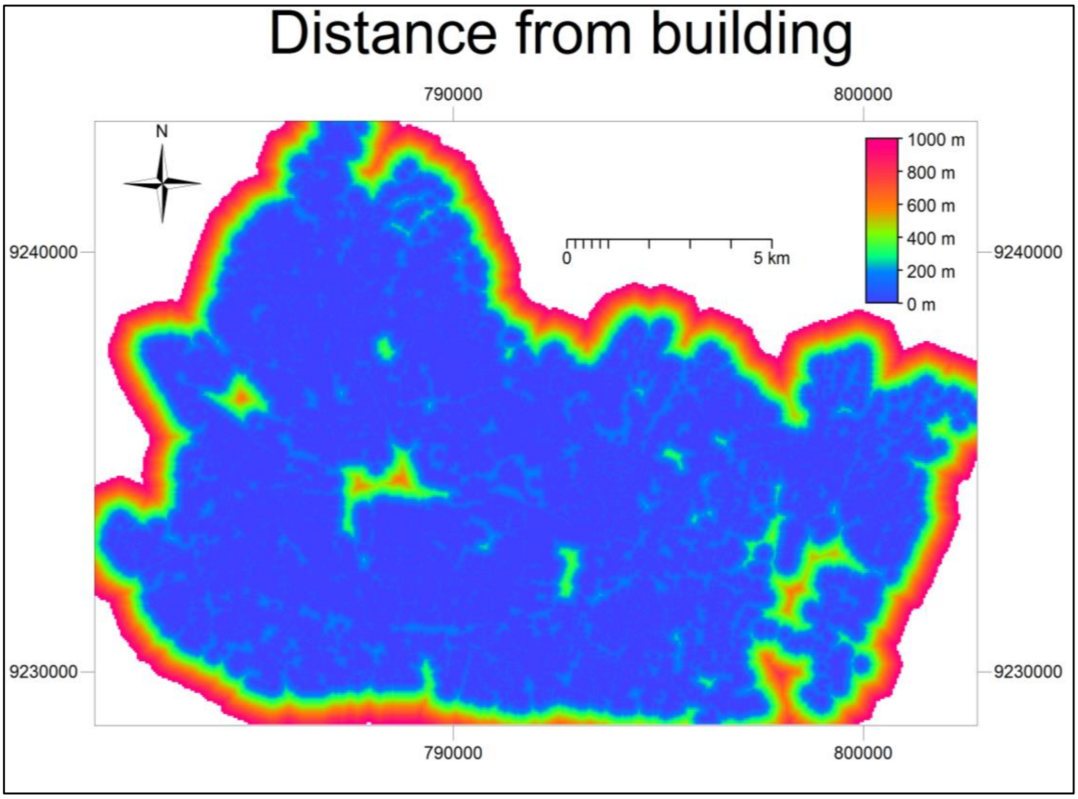


Figure 4.5 Distance from Building map

The nearby principle, the nearer the evacuation area to populated areas, the faster and more comfortably people can seek. Shelter should be evenly distributed so that refuge can arrive there quickly before-in-after disaster it is advisable to have walking distance between 5-10 min (Wei et al., 2012).

Access to the evacuation area is the initial condition for all relief and planning efforts. Evacuation area must be safe for people transferred there from danger and should be available but also the distance between building blocks and the safe area should not be more than a defined threshold in this study used the threshold 1 km or 1000 m based on previous study by (Naghdi et al., 2008).

Distance from building is a cost criteria it is a criteria that contributes negatively to the suitability map (the less the distance the better it is)

4.1.3.2. Distance from road network

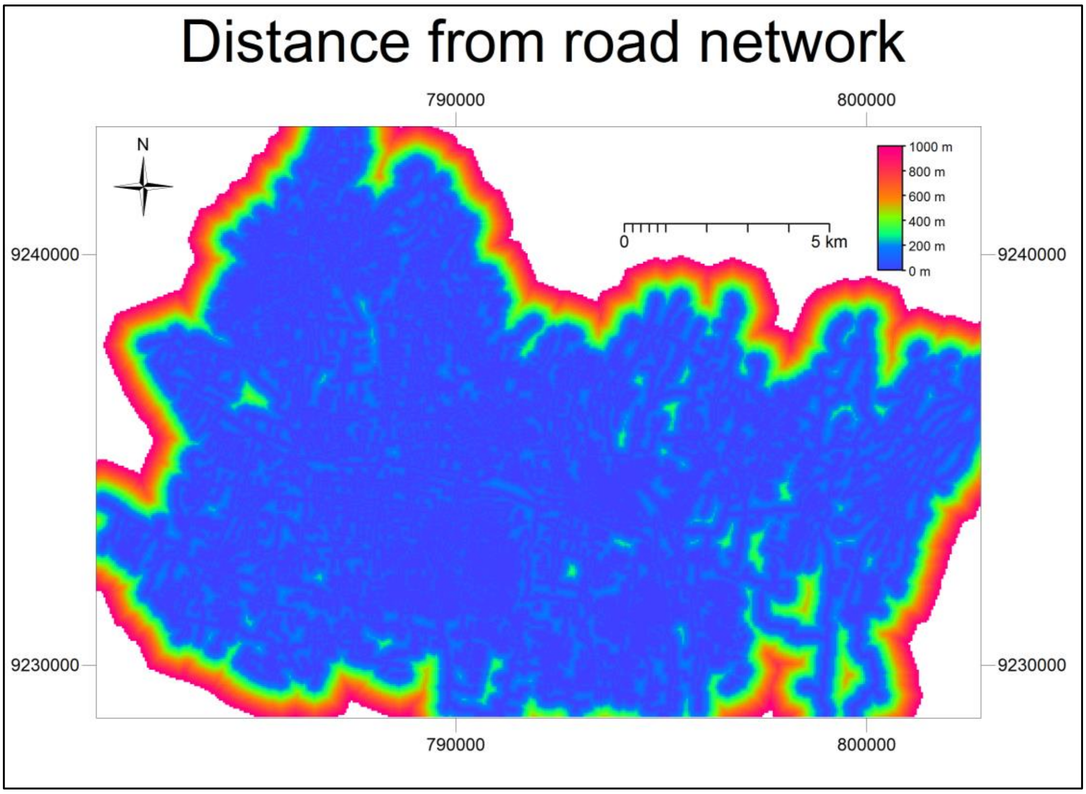


Figure 4.6 Distance from road network map

People seeking shelter rely on some sort of existing and suitable network (roads) to access available shelter areas within a certain time (Tai, Lee, & Lin, 2010). The optimum path between each building blocks and the safe area located in a suitable distance, should be searched and determined by roads network in this study used the threshold 1 km or 1000 m based on previous study by (Naghdi et al., 2008).

The proximity to main roads and accessibility of essential communal services, facilities and natural resources for daily use should be considered when selecting the site. There should be appropriate access to and from the site for emergency services to get sufficiently close to shelters, as well as for the supply of building materials for incremental upgrading and any distributions (IOM, 2012).

Distance from road network is a cost criteria it is a criteria that contributes negatively to the suitability map (the less the distance the better it is)

4.1.3.3. Capacity accommodation

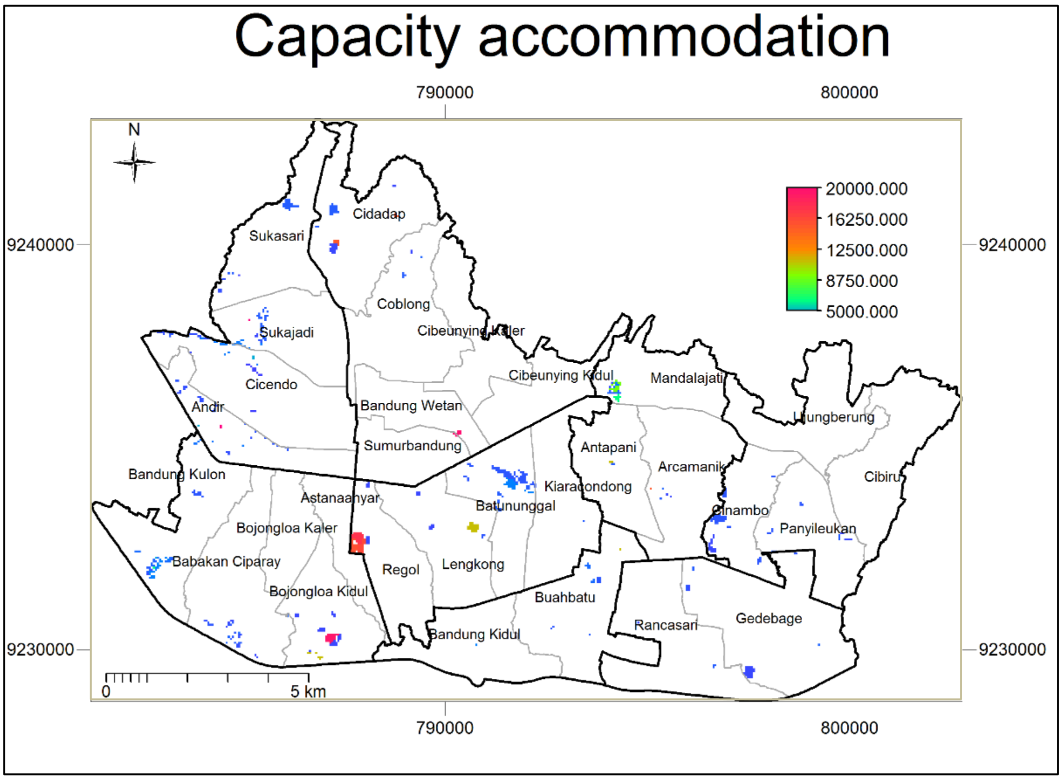


Figure 4.7 Capacity of accommodation map

An seismic shelter for evacuation is designed to received a large number of people, therefore geographical location, i.e., the number of people the site serves, should be considered. The size of the seismic shelter for evacuation is an important aspect of safety evaluation and control (Chu & Su, 2012). An appropriate effective area not only provide refugees with greater space of activities but also facilitates dispersion and management.

Based on (The SPHERE Project, 2011) for a settlement to be spacious, at least 3.5 square meters covered living space should be assigned to each person in the shelter area. Also, there should be at least 45 square meters space assigned for utilities such as roads, sanitation, health, education and nutrition if these services are to be provided within the shelter area. Moreover, the number of people the shelter serves (capacity) should be considered a large camps of over 20,000 people should generally be avoided (UNHCR, 2007).

In this study to calculate capacity of accommodation of urban parks is divided urban parks area with by 3.5 M^2 accounts for accommodation persons.

4.1.3.4. Slope

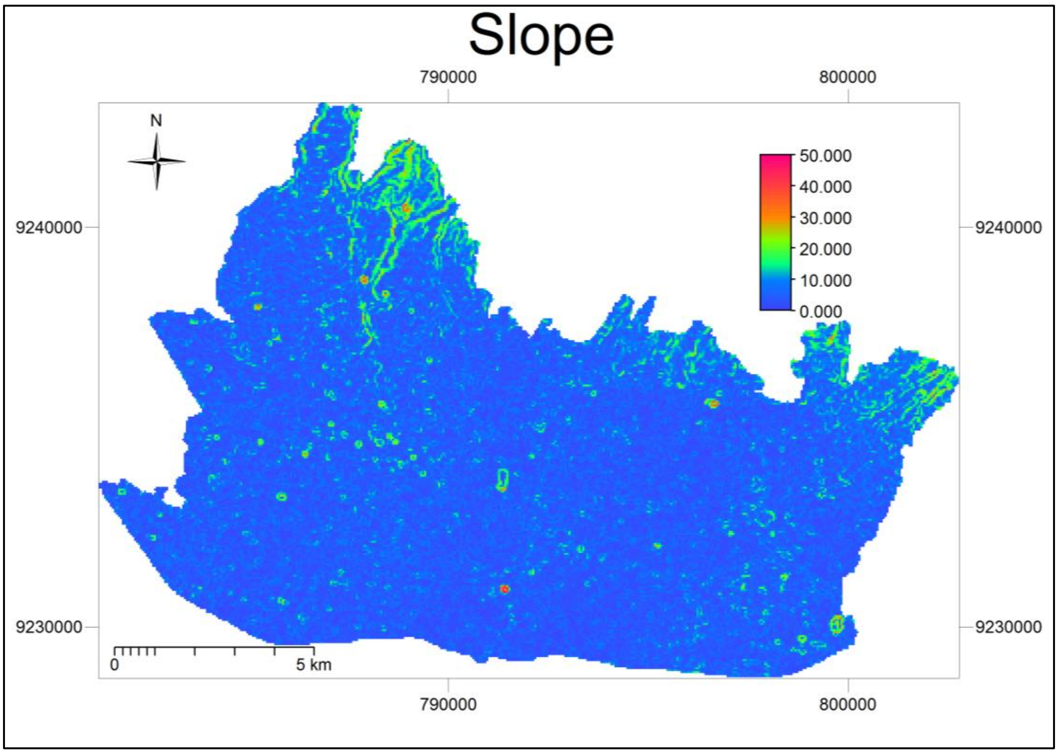


Figure 4.8 Slope map

Bandung city mostly have a flat terrain less than 10 degree except for the north area of the city slope is stepper than 25 degree. Shelter located in slopes steeper than 25 degree are considered to have a high risk of geo hazards whereas slopes less than 5 degree are regarded as stable and secure (Liu et al., 2011). Slope > 25 degree has been defined as a constraint. In the suitability factory is used slope that < 25 degree.

Slope is a cost criteria it is a criteria that contributes negatively to the suitability map (the less the degree the better it is)

4.1.3.5. Earthquake Intensity Zone

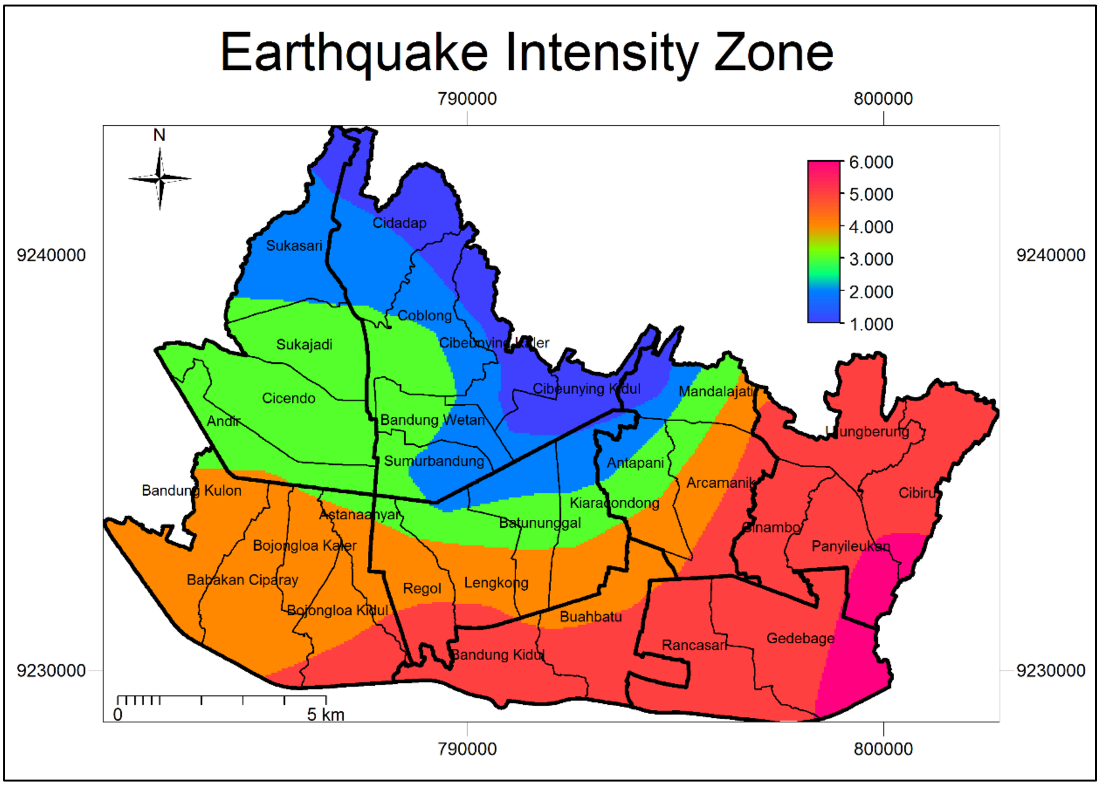


Figure 4.9 Earthquake intensity zone map

The analysis of seismic hazards and risks in Bandung city used the RADIUS, it is the latest comprehensive study concerning earthquake disaster assessment in Bandung (UN IDNDR, 2000). The risk analysis result showed that the earthquake might lead to a variety of severe damage that could be illustrated with Modified Mercalli Intensity (MMI) scale 8 to 9 that can divided into 6 intensity zone (zone 1 = MMI scale 8, zone 2 = MMI scale 8.25, zone 3 = MMI scale 8.5, zone 4 = MMI scale 8.75, zone 5 = MMI scale 9, zone 6 = MMI scale 9.25). The region with the highest intensity was district Cibiru and Panyileukan and the lowest intensity area was districts Cibeunying Kaler and Cibeunying Kidul.

Earthquakes pose a severe risk to shelters. The risk analysis results could be used to select sites that are a reasonable distance from highly damaged areas. Moreover, areas with low damage could serve as the location of the site. It should be ensured that the shelter can minimised risk from natural hazards including earthquakes, volcanic activity, landslides, flooding or high winds area(The SPHERE Project, 2011).

Earthquake intensity zone is a cost criteria it is a criteria that contributes negatively to the suitability map (the less the zone the better it is)

4.1.3.6. Distance from water network

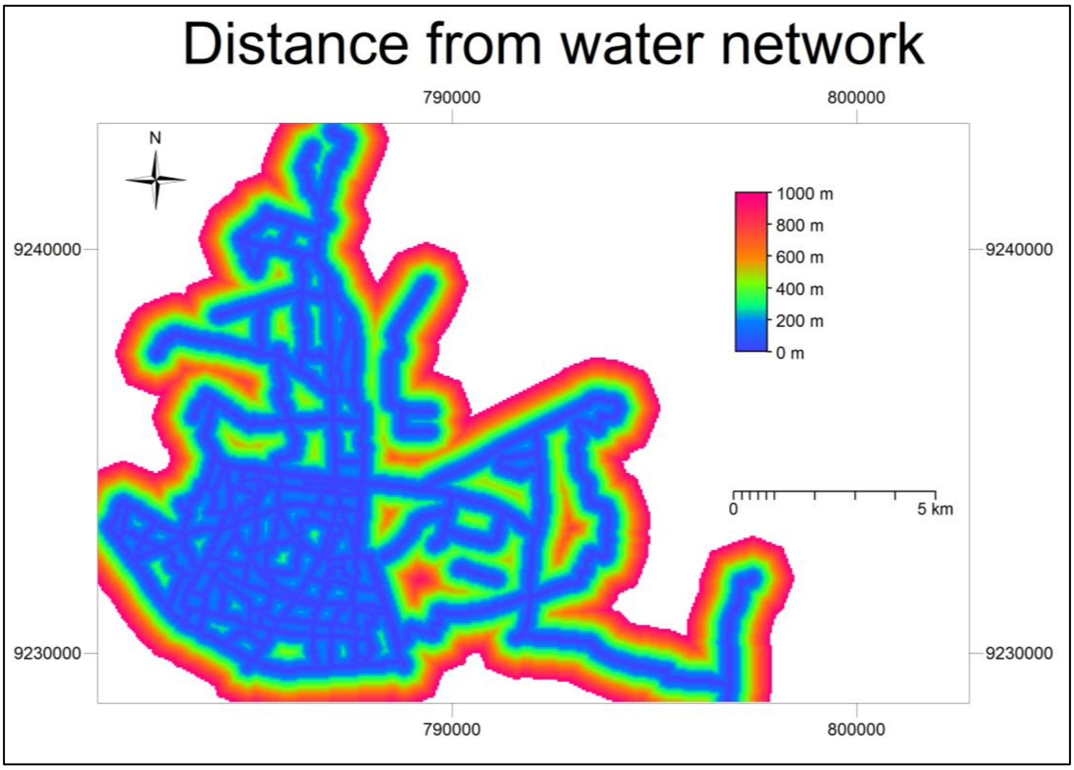


Figure 4.10 Distance from water network map

Water is one of the most important needs of humankind. The site should have access to a clean water supply in order to ensure good health, sanitation and cooking needs, in both the short and long term. Trucking should not be assumed assessment as a sustainable solution, unless it was in use previously and the service remains functional(IOM, 2012). Temporary shelter for evacuation area should be able to provide water service. Therefore, such a site should be located as near as possible with water network. Generally, groundwater sources are preferable as they require less treatment(The SPHERE Project, 2011).

The city's clean water supplier is a municipality-owned company called Perusahaan Daerah Air Minum (PDAM)Bandung, Until 2012, PDAM Bandung only distributed to around 1.6 million people of Bandung, which means that almost half of the population still does not have access or at least a piped connection to clean water (Tarigan et al., 2015). It can be seen from Figure 4.10 that water network it is not available in east part of Bandung city and this conditions will affect the suitability of urban parks in that area.

Distance from water network is a cost criteria it is a criteria that contributes negatively to the suitability map (the less the distance the better it is)

4.1.4. Weighting

Weighting to identify the relative importance of each factor in this study experts are involved to give weight for each factor using pair wise comparison.

Firstly, the suitability factor for assessing urban green spaces were determined and a hierarchical structure established for the study. Secondly, pairwise comparison matrices were formed among the factor. Ratings of factor used in comparisons were assigned using a team of experts (spatial planning from government Bandung Municipality, disaster mitigation from , disaster risk management, and enviromental planning) . See Appendix 2 for list of experts.

In the below is a pairwise comparison matrix from the experts:

Table 4.1 Pairwise comparison matrix from spatial planning expert

	Capacity of accommodation	Slope	Earthquake intensity zone	Distance from building	Distance from road network	Distance from water network
Capacity of accommodation		3.0	1.0	3.0	3.0	3.0
Slope			7.0	3.0	3.0	3.0
Earthquake intensity zone				3.0	3.0	3.0
Distance from building					1.0	1.0
Distance from road network						1.0
Distance from water network	Incon: 0.02					

Table 4.2 Pairwise comparison matrix from disaster mitigation expert

	Capacity of accommodation	Slope	Earthquake intensity zone	Distance from building	Distance from road network	Distance from water network
Capacity of accommodation		3.0	3.0	3.0	3.0	1.0
Slope			1.0	3.0	3.0	3.0
Earthquake intensity zone				5.0	3.0	1.0
Distance from building					3.0	3.0
Distance from road network						2.0
Distance from water network	Incon: 0.09					

Table 4.3 Pairwise comparison matrix from disaster risk management expert

	Capacity of accommodation	Slope	Earthquake intensity zone	Distance from building	Distance from road network	Distance from water network
Capacity of accommodation		3.0	3.0	9.0	5.0	5.0
Slope			1.0	9.0	1.0	1.0
Earthquake intensity zone				9.0	1.0	1.0
Distance from building					9.0	9.0
Distance from road network						1.0
Distance from water network	Incon: 0.04					

Table 4.4 Pairwise comparison matrix from environmental planning expert

	Capacity of accommodation	Slope	Earthquake intensity zone	Distance from building	Distance from road network	Distance from water network
Capacity of accommodation		5.0	3.0	3.0	5.0	5.0
Slope			1.0	1.0	3.0	3.0
Earthquake intensity zone				3.0	3.0	3.0
Distance from building					1.0	1.0
Distance from road network						1.0
Distance from water network	Incon: 0.06					

After pairwise comparison matrix from the experts is constructed, the eigenvector is extracted from the comparison matrix and used as weight coefficients in the factor. These weights are used for calculating the value of the suitability when integration of AHP and GIS(Cengiz & Akbulak, 2009). The accuracy of the weight results depends on the consistency of judgments in the pairwise comparisons. The parameter used for controlling consistency is called the consistency ratio (CR) see Table 4.5.

Table 4.5 Factor weight from expert

No	Factor	Factor weight from experts			
		Spatial planning	Disaster mitigation	Disaster risk management	Enviromental planning
1	Distance from building	0.113	0.051	0.631	0.140
2	Distance from road network	0.113	0.087	0.049	0.127
3	Capacity of accomodation	0.290	0.147	0.166	0.046
4	Slope	0.050	0.214	0.052	0.265
5	Earthquake intensity zone	0.322	0.255	0.052	0.294
6	Distance from water network	0.113	0.247	0.049	0.127
	CR	0.020	0.090	0.040	0.060

All consistensy ratio from the experts is less than 0.1. Consistensy is accepted. Table 4.6 below was calculated average weighting factor from all experts for use in suitability analysis. The highest weight is distance from building 23,4 % followed by earthquake intensity zone 23,1 %, capacity of accomodation 16,2 %, slope 14,5 %, distance from water network 13,4 % and distance from road network 9,4 %.

Table 4.6 Average weighting factor

Factor	Average weighting factor	%
Distance from building	0.234	23.4
Distance from road network	0.094	9.4
Capacity of accomodation	0.162	16.2
Slope	0.145	14.5
Earthquake intensity zone	0.231	23.1
Distance from water network	0.134	13.4

4.1.5. Discussion on method for assessing suitability of urban green spaces as evacuation area

The overlay methods, perform fundamental role in land use suitability in the form of Boolean (AND and OR) operations and weighted linear combination (WLC) (Malczewski, 2004). The essential reason for the popularity of these methods is that they are easy to apply within the GIS environment using map algebra operations and also easy to understand to decision makers. It is suggested that Boolean operations and WLC methods oversimplify the complexity by concentrate on the facts rather than a right combination of facts and value judgments. This condition can be eliminated by integrating GIS and multi criteria decision making methods (MCDA). One of major advantage of integrating MCDA techniques into GIS-based procedures is that the decision-makers can insert their preferences in suitability factor into GIS-based decision-making procedures, and get feedback for evaluation (Mighty, 2015).

Methods use in this study is Multi Criteria Analysis. To spatially implement multi criteria analysis it used Spatial Multi Criteria Evaluation (SMCE) module of Integrated Land and Water Information System (ILWIS)(ITC, 2001). ILWIS is an open sources raster and vector software developed by ITC. SMCE designed and implemented to help the combination of information from a variety of sources to support planning and decision making processes.

SMCE such an interactive modelling process is that stakeholders can actively be involved in the planning and decision-making process. Within a couple of minutes criteria, valuation and weights can be changed and create a new suitability map. This makes the whole assessment process more transparent and easy to visually to illustrate the implications of spatial decisions.

The input of SMCE application is a set of raster maps of certain area (criteria). Next, identifying and structuring criteria that should be considered for assessing suitability of urban green spaces. The most important in structuring criteria is the determination of appropriate suitability factor (Omidvar et al., 2013). In previous disasters, the selection of temporary shelter sites only based on limited factor such as landownership and land per capita and at the end only resulted in the use of arid lands. In this study used public urban parks as these can be managed easier than privately owned open spaces(FEMA, 2007).

Based on(The SPHERE Project, 2011) not only ownership in urban parks that must be considered in site selection temporary shelter. Another factor is the current type of use and future planning. A playground or a park is best suited for shelter since their existing type of use does not restrict the camp development. Institutional or educational function it should not set as a shelter, because of the daily activities function and potentially unstable building conditions that can endangered people. The future planning indicator gives an update suggestion regarding existing using. Some sites have existing long or even short-term plans in place, are already under partial or complete construction, and should exclude. During the site visits, some of the function of places maybe changing and considered as the least suitable ones. The rationale behind this category indicates possible restrictions in access or continuing use. Criteria for site selection temporary shelter in this study is based on 6 criteria: distance from building, distance from road network, capacity of accommodation, slope, earthquake intensity zone and distance from water network. It is better to add current type of use and future planning factor to the suitability analysis. Moreover, water network it is an important factor for site selection temporary shelter as it basic service for the refugees. Unfortunately, water network is not available in the east part of the city and will affect the suitability for urban parks in that area

Next step is added the criteria into the criteria tree whereas criteria are grouped and standardized. For weighting, methods that widely use is decision making problem is The Analytical Hierarchy Process (AHP) (Abella & Van Westen, 2007). AHP create a hierarchy of decision elements (factors) and then making comparisons between possible pairs in a matrix to give a weight for each element and also a consistency ratio. The AHP is effective in evaluating problems involving multiple and diverse criteria, and it can provide a methodological framework that can both detect and correct the inconsistencies in judging the relative importance of factors in a site suitability analysis. However, due to the fast-growing number of pairwise comparisons it is not sensible to use the method for a large set of criteria. From AHP results, the highest weight for suitability factor is distance from building 23,4 % followed by earthquake intensity zone 23,1 %, capacity of accomodation 16,2 %, slope 14,5 %, distance from water network 13,4 % and distance from road network 9,4 %.

4.2. Evaluate the methods on the basis of Bandung Case

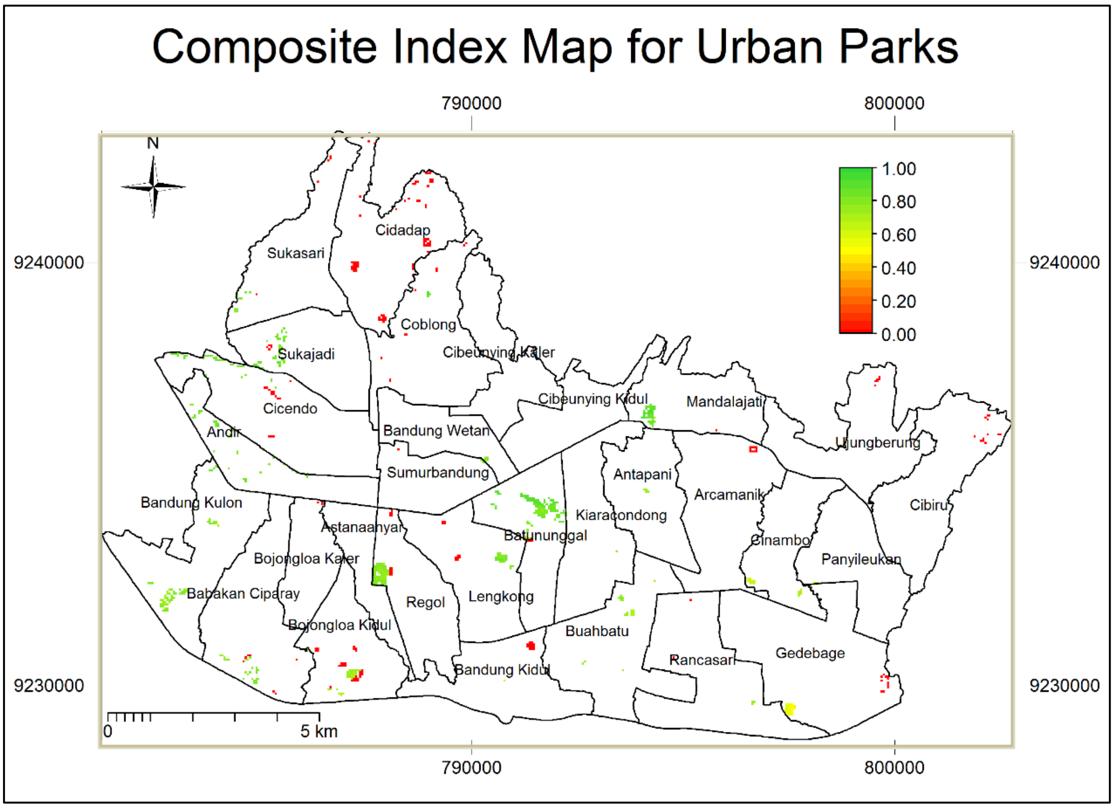


Figure 4.11 Composite index map for urban parks

After all factor have weight based on pairwise comparison from the expert. Next is calculation Weighted Summation Equation (the sum of weight from each factor =1) to obtain the composite index map. The composite index map is the suitability of each pixel of urban parks from 0 (less suitability) until 1 (high suitability) see Figure 4.11. Any output composite index map will have values between 0 and 1. Values near 0 represent less suitable areas By contrast, values near 1 represent suitable areas.

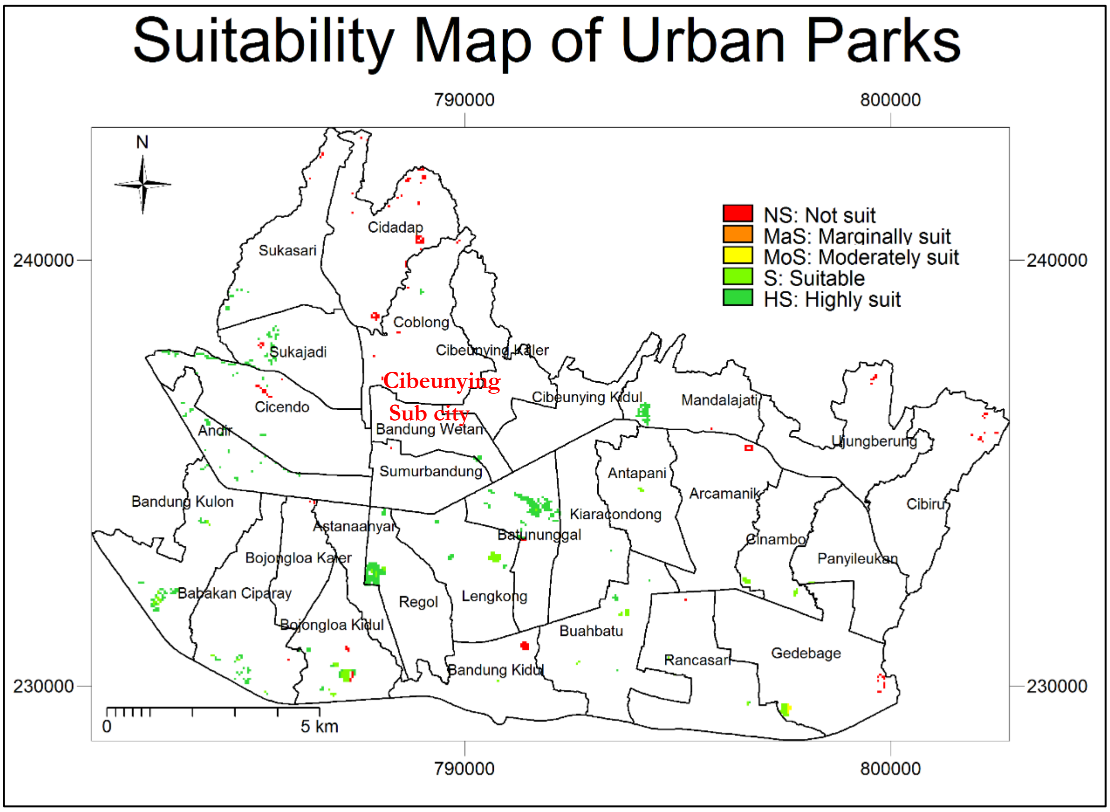


Figure 4.12 Suitability Map of Urban Park

For reclassify the composite index map into the suitability class map it used slicing tools in ILWIS. For this study it used following suitability classes: Not suitable (NS), Marginally suitable(MaS), Moderately suitable(MoS), Suitable(S) and Highly suitable (HS) see Figure 4.12

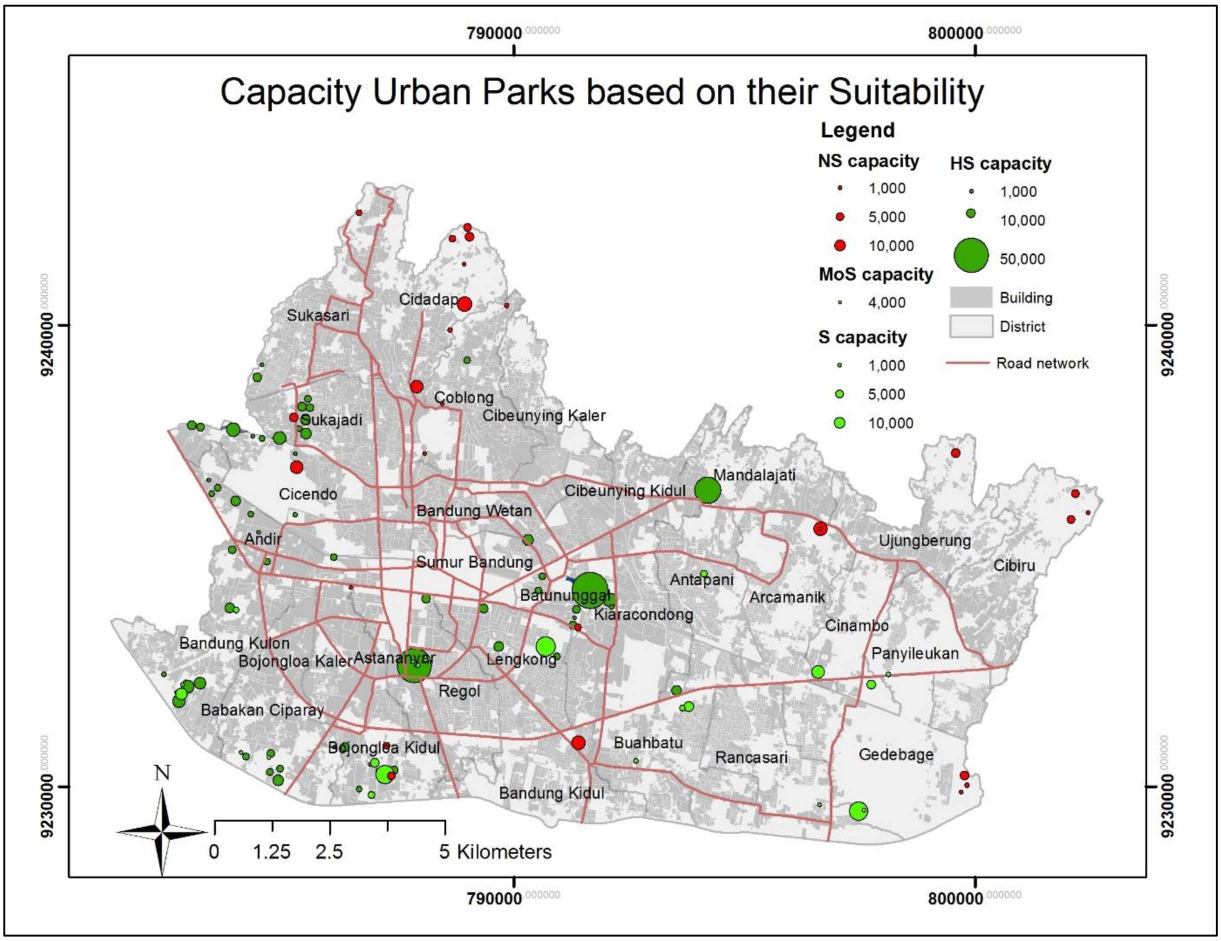
Suitability Map of Urban Parks (see Figure 4.12) is dominated by " highly suitable" class in the central and west part of the city. Moreover, for "not suitable" class is mostly located in the east and north part of the city. Although Cibeunying sub city have the highest number of urban parks and mostly is historical urban parks from the Dutch Indies government but from the suitability analysis mostly it is not suitable because categorized as landslide prone area and have slope > 25 degree. Furthermore suitability analysis also found east part of the city is not suitable because of no water network available and categorized as highest earthquake intensity zone area

From the result suitability analysis from 275.6 hectares of urban parks in Bandung city: 37,8 hectare is Not Suitable, 0 hectare Marginally suitable, 1,8 hectare Moderatelly suitable 34,8 hectare Suitable and 118,3 hectare highly suitable. Moreover, 82.9 hectare can't use in suitability analysis because have constraint in minimum area , slope or landslide. For details see Tabel 4.7

Table 4.7 Urban parks suitability class area

No	Sub City	Parks (ha)	Parks Suitability Class				
			NS	Mas	Mos	S	HS
A	**Sub city Bojonegara**						
1	Andir district	9.1	0.0	0.0	0.0	0.0	8.5
2	Sukasari district	4.8	1.0	0.0	0.0	0.0	2.5
3	Cicendo district	11.8	2.8	0.0	0.0	0.0	9.8
4	Sukajadi district	23.7	1.3	0.0	0.0	0.0	10.8
B	**Sub city Cibeunying**						
5	Cidadap district	11.7	12.5	0.0	0.0	0.0	0.0
6	Coblong district	23.3	2.0	0.0	0.0	0.0	1.0
7	Bandung Wetan district	15.9	0.0	0.0	0.0	0.0	1.5
8	Cibeunying Kidul district	1.4	0.0	0.0	0.0	0.0	0.0
9	Cibeunying Kaler district	3.0	0.0	0.0	0.0	0.0	0.0
10	Sumur Bandung district	6.2	0.3	0.0	0.0	0.0	0.5
C	**Sub city Tegalega**						
11	Astana Anyar district	0.9	0.0	0.0	0.0	0.0	0.0
12	Bojongloa Kidul district	23.4	2.3	0.0	0.0	8.0	4.3
13	Bojongloa Kaler district	1.0	0.8	0.0	0.0	0.0	0.0
14	Babakan Ciparay district	6.9	0.3	0.0	0.0	1.3	7.0
15	Bandung Kulon district	15.8	0.0	0.0	0.0	3.5	11.3
D	**Sub city Karees**						
16	Regol district	20.9	0.0	0.0	0.0	2.0	18.8
17	Lengkong district	8.2	0.0	0.0	0.0	5.5	3.5
18	Batununggal district	27.9	1.0	0.0	0.0	0.3	27.0
19	Kiaracondong district	0.9	0.0	0.0	0.0	0.0	0.3
E	**Sub city Arcamanik**						
20	Mandalajati district	10.1	0.3	0.0	0.0	0.0	9.5
21	Antapani district	2.3	0.0	0.0	0.0	1.0	0.0
22	Arcamanik district	16.4	2.5	0.0	0.0	0.0	0.0
F	**Sub city Ujungberung**						
23	Cinambo district	5.0	0.0	0.0	0.0	3.8	0.0
24	Panyileukan district	2.8	0.0	0.0	0.0	0.8	0.0
25	Ujungberung district	0.7	1.5	0.0	0.0	0.0	0.0
26	Cibiru district	0.8	3.3	0.0	0.0	0.0	0.0
G	**Sub city Kordon**						
27	Bandung Kidul district	2.6	3.3	0.0	0.0	0.3	0.0
28	Buahbatu district	4.8	0.0	0.0	0.0	2.8	2.0
H	**Sub city Gedebage**						
29	Gedebage district	10.0	2.8	0.0	1.8	4.8	0.0
30	Rancasari district	3.2	0.3	0.0	0.0	1.0	0.3
	Total all area	275.6	37.8	0.0	1.8	34.8	118.3

Figure 4.13 Capacity urban parks based on their suitability



Capacity of urban parks is calculated from urban parks area divided by 3.5 M² per person a minimum requirement stated in(The SPHERE project,2011) from Figure 4.13 it can be seen that urban parks located in district Regol, Batununggal and Mandalajati is a "highly suitable" and high capacity of urban parks.

In Table 4.8 is the comparison between the capacity highly suitable (HS) urban parks with the estimation of refugee. Estimation refugee is calculated by multiplying the damaged building/ district from The RADIUS project (Tabel 1.1) with average person per household/district form (Central Bureau Statistic of Indonesia, 2014).

Table 4.8 explain that "highly suitable" urban parks not located in all district in Bandung City. Urban parks can't afford all of estimation refugees for about 1.259.921 person it is only can afford 337.857 person or 27 % from the total estimation refugees. Its need additional area for accommodated all of the refugee. Public facilities such as schools, hospitals, and stadiums are generally suitable for use as a shelters (Liu et al., 2011)

Table 4.8 Comparison capacity urban parks and estimation of refugee

No	Sub City	HS Parks	Capacity (person)	Estimation refugee
A	**Sub city Bojonegara**			
1	Andir district	8.5	24286	49392
2	Sukasari district	2.5	7143	28468
3	Cicendo district	9.8	27857	35024
4	Sukajadi district	10.8	30714	27321
B	**Sub city Cibeunying**			
5	Cidadap district	0.0	0	13860
6	Coblong district	1.0	2857	70758
7	Bandung Wetan district	1.5	4286	12372
8	Cibeunying Kidul district	0.0	0	24488
9	Cibeunying Kaler district	0.0	0	23330
10	Sumur Bandung district	0.5	1429	23964
C	**Sub city Tegalega**			
11	Astana Anyar district	0.0	0	64092
12	Bojongloa Kidul district	4.3	12143	25008
13	Bojongloa Kaler district	0.0	0	71505
14	Babakan Ciparay district	7.0	20000	52172
15	Bandung Kulon district	11.3	32143	53596
D	**Sub city Karees**			
16	Regol district	18.8	53571	80968
17	Lengkong district	3.5	10000	34060
18	Batununggal district	27.0	77143	79158
19	Kiaracondong district	0.3	714	37204
E	**Sub city Arcamanik**			
20	Mandalajati district	9.5	27143	20200
21	Antapani district	0.0	0	79336
22	Arcamanik district	0.0	0	30300
F	**Sub city Ujungberung**			
23	Cinambo district	0.0	0	52110
24	Panyileukan district	0.0	0	21412
25	Ujungberung district	0.0	0	60795
26	Cibiru district	0.0	0	38520
G	**Sub city Kordon**			
27	Bandung Kidul district	0.0	0	25008
28	Buahbatu district	2.0	5714	41416
H	**Sub city Gedebage**			
29	Gedebage district	0.0	0	35035
30	Rancasari district	0.3	714	49049
	Total	118.3	337857	1.259.921

To check the accuracy of the method and the existing conditions, the "highly suitable" and high capacity of urban parks in Regol, Batununggal and Mandalajati district is overlay with Open street map and Digital globe imagery that available from ESRI basemap in ArcGIS.

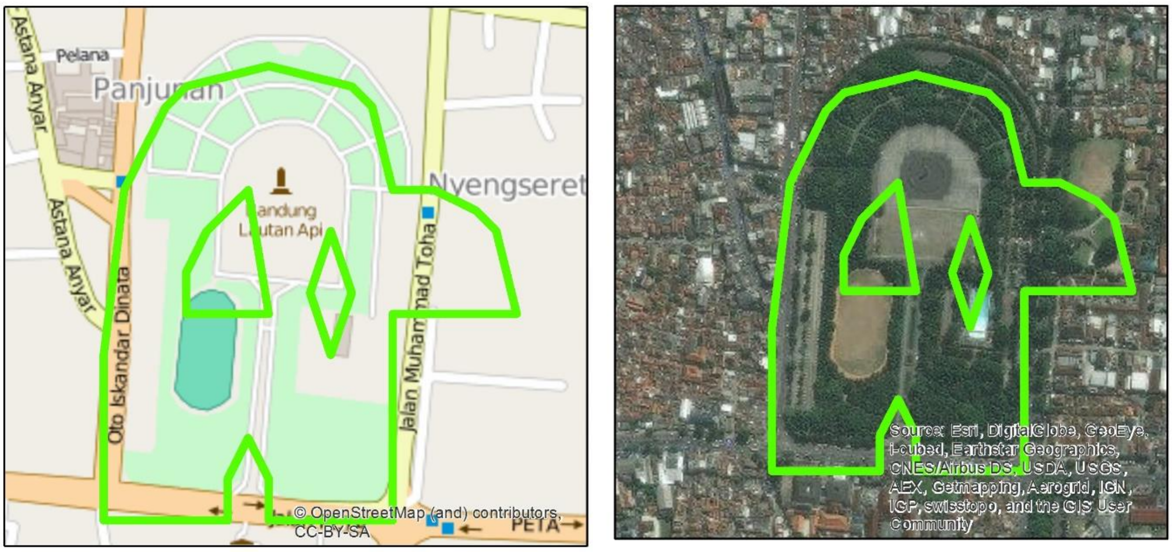


Figure 4.14 Tegallega parks in Regol district

Location in Regol district is Tegallega parks (18.8 ha) see Figure 4.14. Existing condition is city park. There is a difference between shape of urban parks spatial data from government agencies with existing condition this uncertainties might affect the validation of the model.

Figure 4.15 Warehouse PT.KAI in Batununggal district

Location in Batununggal district is warehouse of PT. Kereta Api Indonesia (27 ha) see Figure 4.15. PT KAI is a government-owned company for operating a trains. Existing condition is green spaces. There is a plan from Major of Bandung City for changing the function of warehouse into urban park/urban forest on 2016.

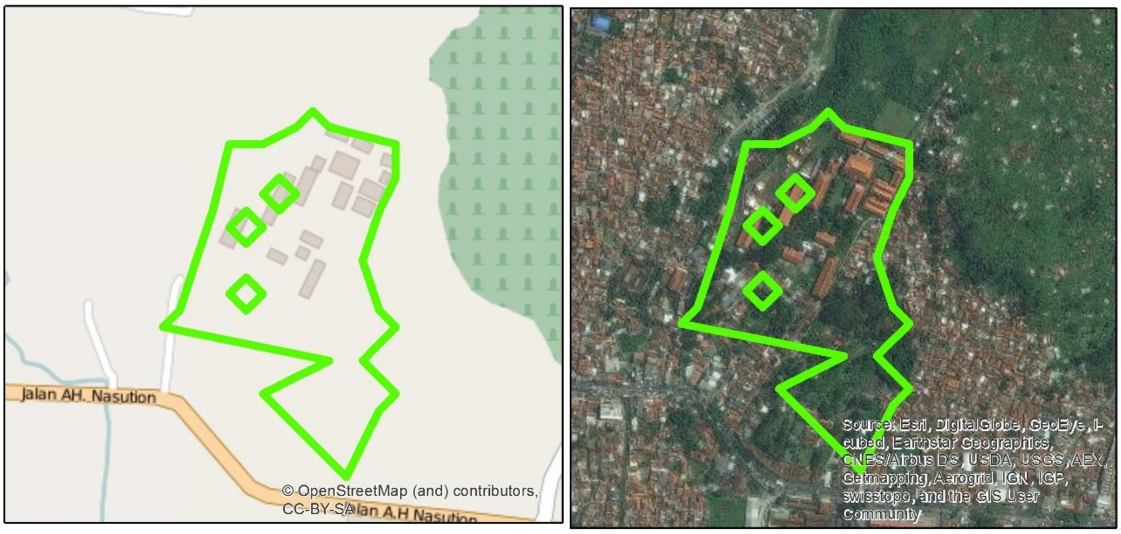


Figure 4.16 PUSBIKTEK in Mandalajati district

Location in Mandalajati district is PUSBIKTEK/training centre of Ministry of Public Works Indonesia (9.5 ha). Existing condition is training centre building and green spaces. This area will exclude from use as temporary shelter because have existing function as training centre

4.2.1. Discussion on evaluate the methods

To make landslide prone area in north part of the city suitable as temporary shelter, several interventions can be done (IOM, 2012): using appropriate site gradient; ground stabilises by vegetation and appropriate soil type to reduces the risk of mud slides.

Moreover for earthquake prone sites in east part of the city, several interventions can be done (IOM, 2012); appropriate distances more than 10 m away from rock faces steep slopes and other buildings; using appropriate soil type and avoid alluvial plains, unstable slopes and unstable soils.

Next for a lack of water network for clean water in east part of Bandung, several interventions can be done; expanding the development of water network until the east part of Bandung for ensure the availability of clean water, trucking service but not a sustainable solution (IOM, 2012) and using groundwater sources because they require less treatment (The SPHERE Project, 2011)

After overlay with open street map and digital globe imagery not all location can use even it is a "highly suitable" area.The future planning must include as a factor in suitability analysis because it gives an update suggestion regarding existing using(The SPHERE Project, 2011). The function of places maybe changing and considered as the least suitable ones. Moreover, there is a differences between shape of urban parks from government agencies spatial data with existing condition this uncertainties might affect the validation of the model. There is a need to update the spatial data in government agencies into the latest existing condition.

5. CONCLUSION

The aim of this chapter are to summarize the study of this research and conclusion of main findings. Lastly, concludes with some recommendations

5.1. Conclusion

5.1.1. To identify the requirements for evacuation areas

There is six criteria for site selection temporary shelter following earthquake from several literatures and standards (The SPHERE Project, 2011; UNHCR, 2007; IOM, 2012;Chu & Su, 2012; Kılcı et al., 2015; Liu et al., 2011; Omidvar et al., 2013; Wei et al., 2012): distance from building, distance from road network, capacity of accommodation, slope, earthquake intensity zone and distance from water network. Based on (The SPHERE Project, 2011) for a settlement to be spacious, at least 3.5 square meters covered living space should be assigned to each person in the shelter area.

5.1.2. To describe the characteristics of existing urban green spaces

Urban green spaces have multiple function not only ecological function as regulating climate, conserving water, purifying the air and protecting biodiversity but also one alternative of temporary shelter. There are 15 types of green open spaces based on Ministerial Regulation of Public Works Indonesia No. 05/PRT/M/200. Not all type of urban green spaces can be used as evacuation area due to their existing function, urban parks is suitable to be used as evacuation area because has characters of a large quantity, wide distribution and easy accessible. This regulation also divide urban parks hierarchy into city and neighborhood parks (local park (*Taman RT/RW*), sub-district park (*Taman kelurahan*) and district park (*Taman kecamatan*). The minimum required area for temporary shelter based on previous study (Chen et al, 2013) is 2000 M^2. Urban parks area that less than 2000 M^2 will excluded from the analysis.

The total urban parks area is Bandung Municipality 275.6 Ha. Moreover, the highest number of urban park area is located in Cibeunying sub city with 147 urban park, while the lowest number located in Tegallega sub city with 28 urban park

5.1.3. To develop a method for assessing urban green space suitability as evacuation areas

This research used Multi Criteria Evaluation methods and to spatially perform multi criteria evaluation it used Spatial Multi Criteria Evaluation module of ILWIS and to determine the weight values between criteria, the Analytic Hierarchy Process (AHP) was adopted. One of major advantage of integrating MCDA techniques into GIS-based procedures is that the decision-makers can insert their preferences in suitability factor into GIS-based decision-making procedures, and get feedback for evaluation (Mighty, 2015). The AHP also can detect and correct the inconsistencies in judging the relative importance of factors in a site suitability analysis This method is commonly used in landscape planning and assessment and in site-suitability analyses (Du, Zhang, & Wang, 2012)

From the AHP result the highest weight for suitability factor is distance from building 23,4 % followed by earthquake intensity zone 23,1 %, capacity of accomodation 16,2 %, slope 14,5 %, distance from water network 13,4 % and distance from road network 9,4 %.

5.1.4. To evaluate the method on the basis of the Bandung case

This research found that urban parks as one alternative for evacuation area. Urban parks is suitable to used as evacuation area because has characters of a large quantity, wide distribution and easy accessible Urban parks can't afford all of estimation refugees, only 27 % from the total estimation refugees. It is need additional area for accommodated all of the refugee. Public facilities such as schools, hospitals, and stadiums are generally suitable for use as a shelters.

5.2. Recommendation

There are several recommendation

- ✓ In the future work would be a great interest and importance to use the earthquake risk assessment based on the latest condition. This research used the earthquake risk assessment in 2000 year from RADIUS Project. The outcomes of the analyse themselves cannot be evaluated as they are based upon outdated data

- ✓ For landslide prone area there is several recommendation for increase the suitability as a shelters (IOM, 2012); using appropriate site gradient; ground stabilises by vegetation and appropriate soil type to reduces the risk of mud slides.

- ✓ For earthquake prone area there is several recommendation for increase the suitability as a shelters(IOM, 2012); appropriate distances more than 10 m away from rock faces steep slopes and other buildings; using appropriate soil type and avoid alluvial plains, unstable slopes and unstable soils.

- ✓ For lack of water network area there is several recommendation for increase the suitability as a shelter; expanding the of water network until the east part of Bandung for ensure the availability of clean water, trucking service but not a sustainable solution (IOM, 2012) and using groundwater sources (The SPHERE Project, 2011)

- ✓ Updating shape and function urban parks in government agencies spatial data into the latest existing condition.

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APPENDIX

1.Questionnare form

QUESTIONNARE

Questionnaire Form/Formulir Kuisioner

Master Programme of Urban Planning and Management

Faculty of Earth Science and Geoinformation/Fakultas Ilmu Kebumian dan Geoinformasi

University of Twente/Universitas Twente

Name: Gentria Ardiputri Paramita (gentria28@gmail.com , +628562124038)
Supervisor: Dr. Denny Zulkaidi, Dr. Richard Sliuzas
Thesis title: Planning of Urban Green Spaces as Evacuation Area in Earthquake Disaster (Case Study: Bandung Municipality)
Expert name:
Workplace:

QUESTIONNARE PAIR WISE COMPARISON

Directions/Petunjuk Pengisian:

Fundamental Scale (Row v Column)	
Extremely less important	1/9
	1/8
Very strongly less important	1/7
	1/6
Strongly less important	1/5
	1/4
Moderately less important	1/3
	1/2
Equal Importance	**1**
	2
Moderately more important	3
	4
Strongly more important	5
	6
Very strongly more important	7
	8
Extremely more important	9

Criterions/Kriteria:
1.Capacity of accommodation/Kapasitas penggunaan RTH
2.Slope/Kemiringan lereng
3.Earthquake Intensity Zone/Zona intensitas gempa bumi
4..Distance from building/Jarak dari bangunan
5..Distance from road network/Jarak dari jalan utama
6.Distance from water network/Jarak dari saluran air

Criterion																		Criterion
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9	
Capacity																		Slope
Capacity																		Earthquake Intensity Zone
Capacity																		Distance from building
Capacity																		Distance from road
Capacity																		Distance from active fault
Capacity																		Distance from water network

Criterion																		Criterion
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9	
Slope																		Earthquake Intensity Zone
Slope																		Distance from building
Slope																		Distance from road
Slope																		Distance from active fault
Slope																		Distance from water network

Criterion																		Criterion
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9	
Earthquake Intensity Zone																		Distance from building
Earthquake Intensity Zone																		Distance from road
Earthquake Intensity Zone																		Distance from active fault
Earthquake Intensity Zone																		Distance from water network

Criterion																		Criterion
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9	
Distance from building																		Distance from road
Distance from building																		Distance from active fault
Distance from building																		Distance from water network

Criterion																		Criterion
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9	
Distance from road																		Distance from active fault
Distance from road																		Distance from water network

Criterion																		Criterion
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9	
Distance from active fault																		Distance from water network

2. Lists of experts

No	Name	Area of Expertise	Workplace
1	Teti Arifiyanti, ST.,MSi.	Spatial Planning	Development Planning Agency Bandung Municipality
2	Aria Mariany, ST., MT.	Disaster mitigation	Research Center for Disaster Mitigation ITB
3	Saut A. Sagala , ST., M.Sc., Ph.D.	Disaster risk management	Urban and Regional Planning Department ITB
4	Ir. Djoko Santoso Abi Suroso, Ph.D.	Environmental planning	Urban and Regional Planning Department ITB